Chapter I. The bones of the axial skeleton. (*Ossa trunci*)

1.1. Anatomy of the vertebra

1.1.1. The vertebral column (Columna vertebralis)

The central axis of the skeleton in all vertebrates is the **vertebral column (Columna vertebralis)**. The vertebral column (spine or backbone) is part of the axial skeleton, which consists of five morphologically differentiated groups of vertebrae and situated in the dorsal aspect of the torso from the skull to the pelvis.

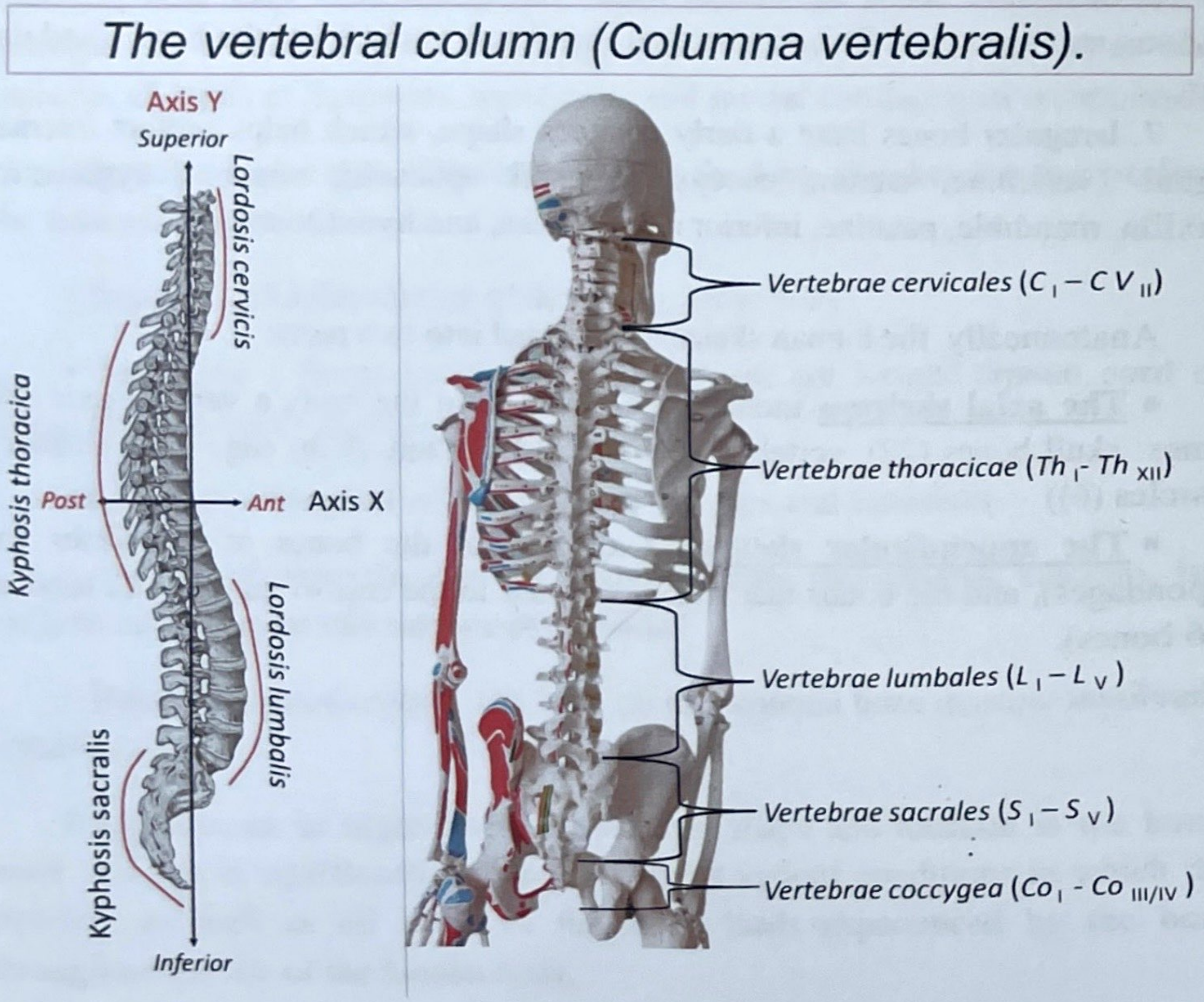

The vertebral column (Columna vertebralis).
Axis Y
Superior
Lordosis cervicis
Kyphosis thoracica
Post
Ant
Axis X
Lordosis lumbalis
Kyphosis sacralis
Inferior
Vertebrae cervicales ($C_{I} – CV_{II}$)
Vertebrae thoracicae (Th_{I}- Th_{XII})
Vertebrae lumbales ($L_{I} – L_{V}$)
Vertebrae sacrales ($S_{I} – S_{V}$)
Vertebrae coccygea (Co_{I} - $Co_{III/IV}$)

Fig. 1. The vertebral column (Columna vertebralis). Sagittal plan right side (original fig.)

The vertebrae provide a column of support, bearing the weight of the head, neck, and trunk, and ultimately transferring weight to the appendicular skeleton. The vertebral column provides attachments to muscles and helps maintain an upright body position, as in sitting or standing. The vertebral column protects the spinal cord, provides a passageway for spinal nerves that begin or end at the spinal cord. Moreover, the backbone serves as a site for haemopoiesis.

The human vertebral column is divided into 5 regions:

- **Cervical region (Pars cervicalis columnae vertebralis)** is formed by 7 vertebrae **(C1–C7).**
- **Thoracic region (Pars thoracica columnae vertebralis)** is formed by 12 vertebrae **(Th1–Th12).**
- **Lumbar region (Pars lumbalis columnae vertebralis)** is formed by 5 vertebrae **(L1–L5).**
- **Sacral region (Pars sacralis columnae vertebralis)** is formed by 5 vertebrae **(S1–S5).**
- **Coccygeal region (Pars coccygea columnae vertebralis)** is formed by 3–5 vertebrae **(Coc1–Coc5).**

Each region of the vertebral column has different functions and, as a result, vertebrae within each region have anatomical specializations that allow for these functional differences. In addition, the vertebrae located at the junction between two regions of the vertebral column will share some anatomical characteristics of the region above and the region below.

The cervical, thoracic and lumbar regions consist of individual vertebrae. During development, the vertebrae of the sacrum fully fuse by the age of 25 and form the sacrum (**Os sacrum**). The coccyx (**Os coccygis**), or "tailbone", is formed by the fusion of three to five very small vertebrae. The distal coccygeal vertebrae do not complete their ossification until puberty, and after that, fusion occurs at a variable rate.

In that way the adult vertebral column consists of 32–35 vertebrae, placed in series and connected by ligaments and intervertebral discs and (or) it consists of 26 bones (!), including the 24 vertebrae, the sacrum, and the coccyx.

Spinal Curves

The vertebral column does not form a straight and rigid structure. A sagittal plan of the adult vertebral column shows four **spinal curves**:

1. **Cervical curve**
2. **Thoracic curve**
3. **Lumbar curve**
4. **Sacral curve**

The cervical and lumbar curvatures are concave anterioly (*curved anterioly*) and named – **Lordosis** (Gk). The thoracic and sacral curvatures are convex anterioly (*curved posteriorly*) and called – **Kyphosis** (Gk).

1.1.2. Vertebral Anatomy

Generally, vertebrae have a common structural plan. Each vertebra has:

- The **vertebral body (Corpus vertebrae)** is the largest anterior cylindrical part of a vertebra that transfers weight along the axis of the vertebral column. The vertebral body has many **nutrient foramina (Foramen nutricia)** which serve the passage of vessels and nerves into the bone substance. The size of the vertebral bodies increases down the spine as the size and weight of the body it has to support above it increase. Each vertebra articulates with neighboring vertebrae above and below it; the bodies are interconnected by ligaments and separated by pads of fibrous cartilage, the **intervertebral discs**.

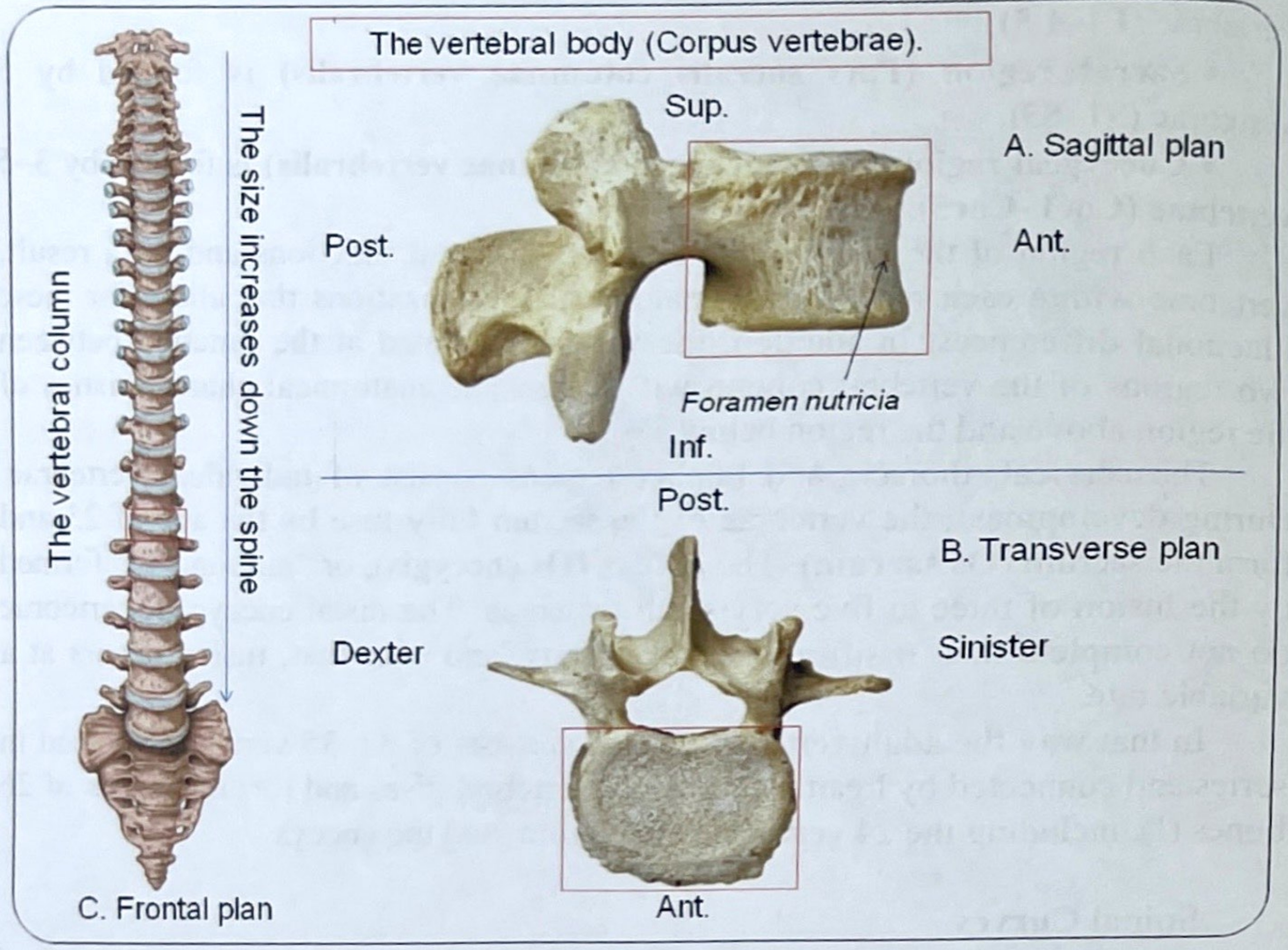


Fig. 2 The vertebral body (Corpus vertebrae) (A. Sagittal plan, B. Transverse plan, C. Frontal plan) (original fig.)

- **The vertebral arch (Arcus vertebrae)** forms the lateral and posterior margins of the **vertebral foramen (Foramen vertebrale)** that in life surrounds a portion (segment) of the spinal cord. The vertebral foramens are placed one above to the other and form **the vertebral canal (Canalis vertebralis)** which encloses the spinal cord. The vertebral foramen has a floor (the posterior surface of the body), walls (the pedicles), and a roof – **the laminae**.

The **pedicles (Pediculus arcus vertebrae)** arise along the posterolateral (posterior and lateral) margins of the body. Each pedicle of the vertebra has an upper notch **(Incisura vertebralis superior)** and a lower notch (*deeper, this helps you to determine the anatomical position of the bone!*) **(Incisura vertebralis inferior).** There are gaps termed **intervertebral foramina (Foramina intervertebrale)** between the notches of pedicles of successive vertebrae. These intervertebral foramina permit the passage of nerves running to or from the enclosed spinal cord. The **laminae** on either side extend dorsomedially (dorsally and medially) to complete the roof.

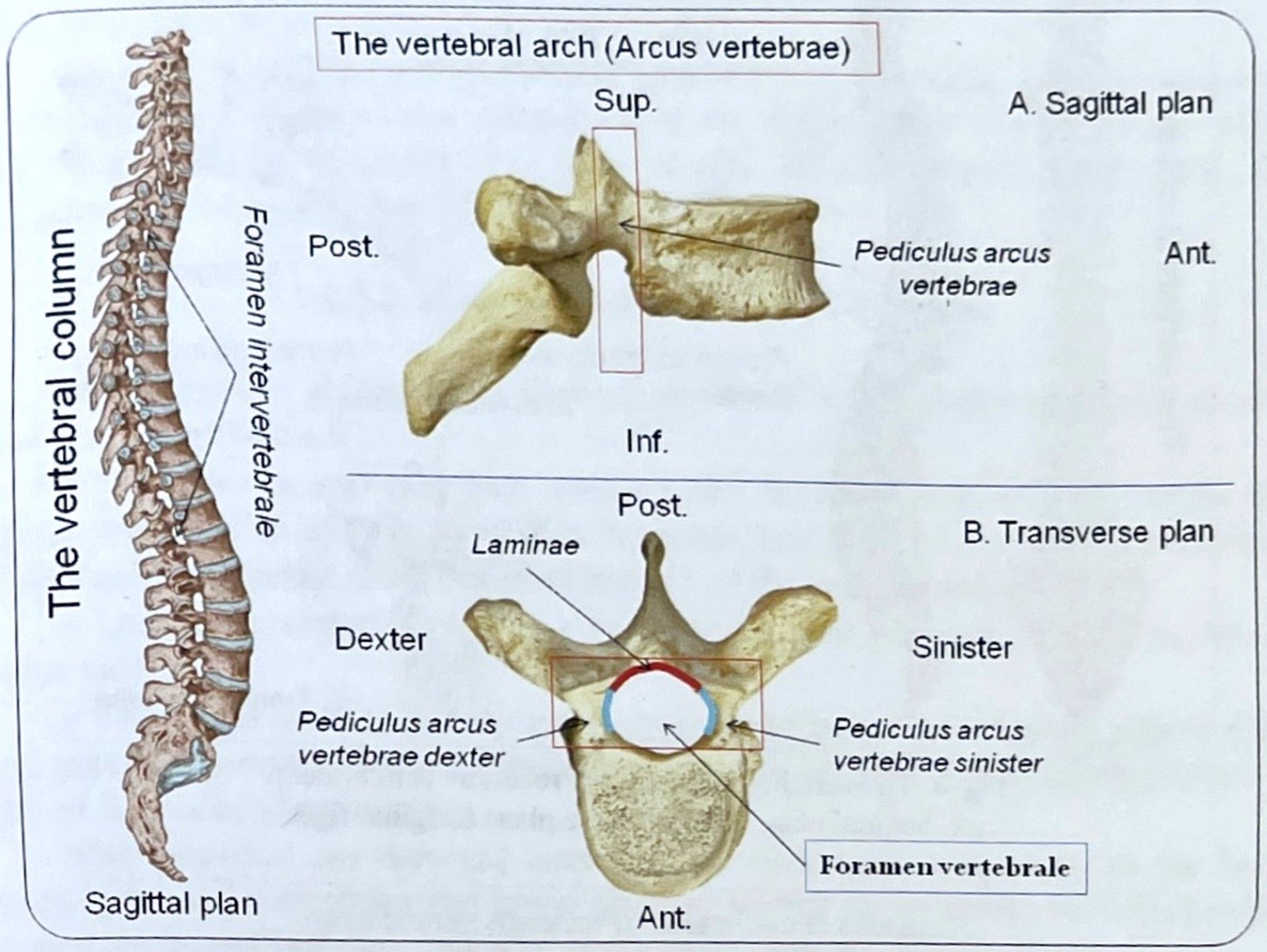


Fig. 3. The vertebral arch (Arcus vertebrae) (A. Sagittal plan, B. Transverse plan) (original fig.)

- **Processes of the vertebrae (Processus vertebrales).** From the posterior surface of the laminae, 3 groups of processes arise (there are 7 processes: 1 spinous process, 2 transverse processes and 4 articular processes)

A spinous process (Processus spinosus) is unpaired, single and projects dorsally from the midline of the posterior surface of the laminae (of the arch). These processes can be seen and felt through the skin of the back.

Left and right transverse processes (Processus transversus dexter et sinister) (paired) project laterally or dorsolaterally on both sides from the point where the laminae join the pedicles. These processes are sites of muscle attachment, and vertebra of the thoracic region also articulate with the ribs.

The **articular processes (Processus articulares superiores et inferiores)** also arise at the junction between the pedicles and laminae. There is a **superior articular process** and an **inferior articular process** on each side of the vertebra.

The inferior articular processes of one vertebra articulate with the superior articular processes of the more caudal vertebra. Each articular process has a polished surface called an **articular facet (Facies articulares superiores et inferiores).** The superior processes have articular facets on their dorsal surfaces, whereas the inferior processes articulate along their ventral surfaces.

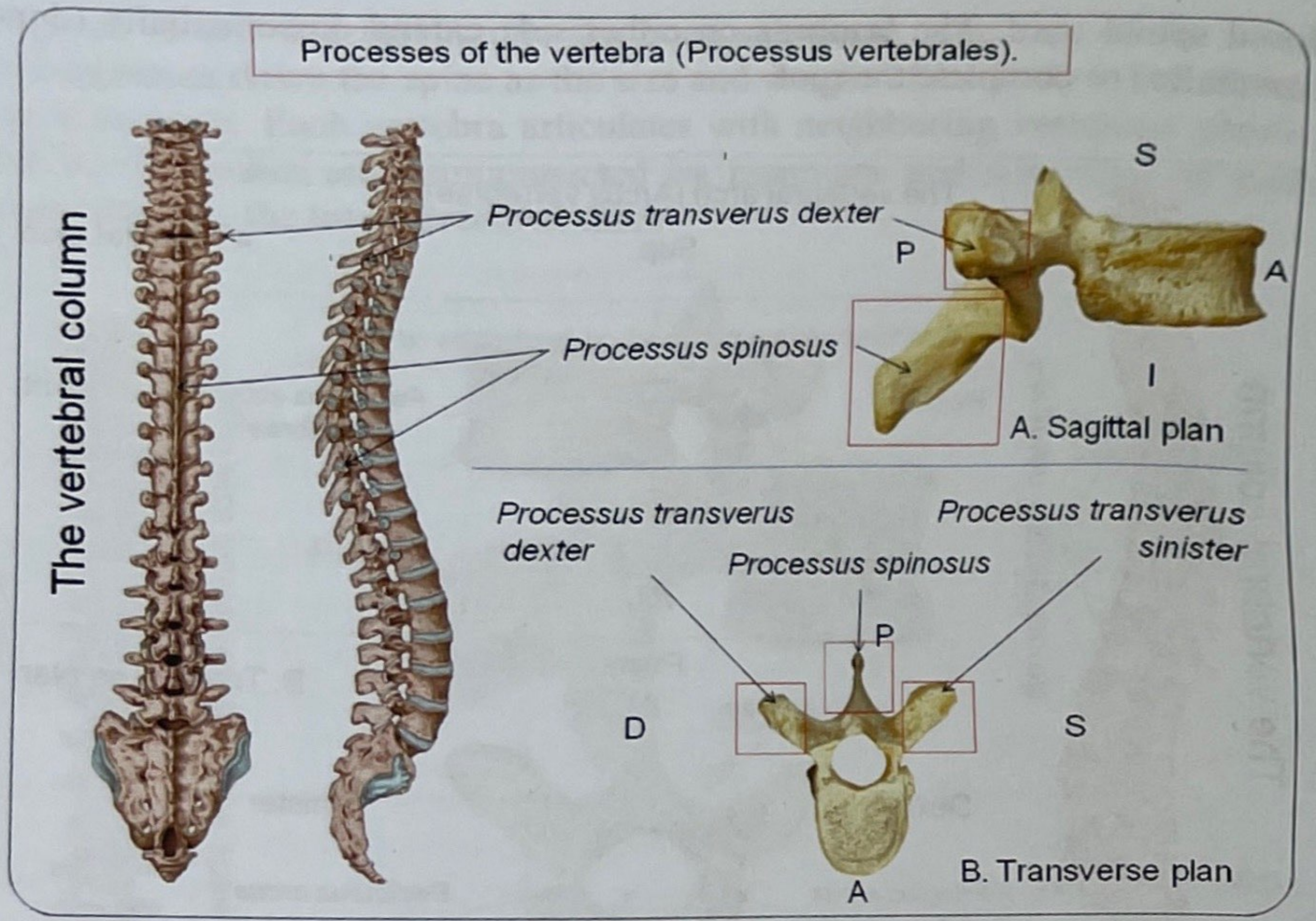

Processes of the vertebra (Processus vertebrales).
The vertebral column
Processus transverus dexter
Processus spinosus
S
P
A
I
A. Sagittal plan
Processus transverus dexter
Processus spinosus
Processus transverus sinister
P
D
S
A
B. Transverse plan

Fig. 4. The vertebral processes (Processus vertebrales).
(A. Sagittal plan, B. Transverse plan) (original fig.)

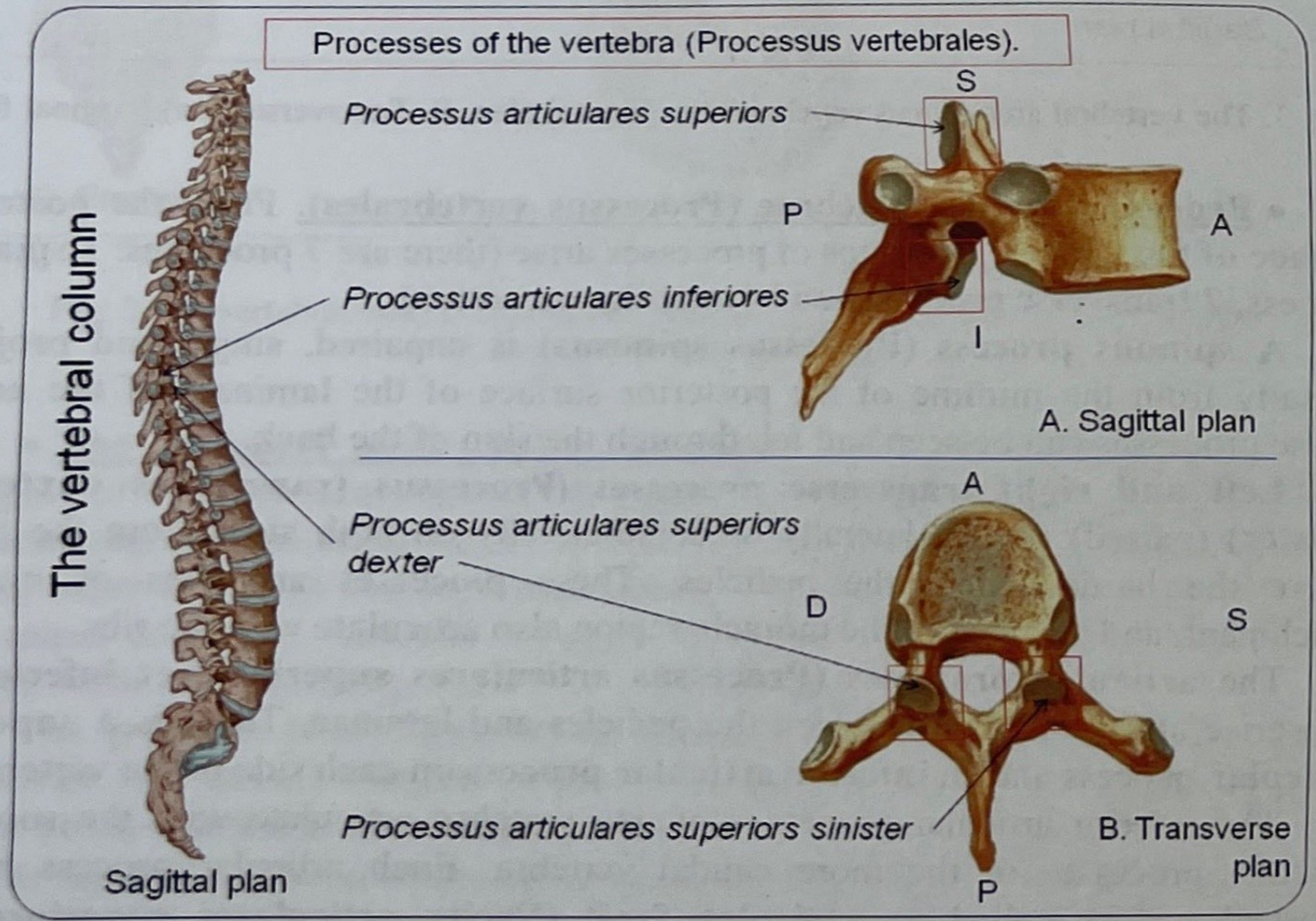

Processes of the vertebra (Processus vertebrales).
S
Processus articulares superiors
P
A
Processus articulares inferiores
I
A. Sagittal plan
The vertebral column
A
Processus articulares superiors dexter
D
S
Processus articulares superiors sinister
B. Transverse plan
P
Sagittal plan

Fig. 5. The vertebral processes (Processus vertebrales).
(A. Sagittal plan, B. Transverse plan) (original fig.)

1.1.3. Cervical vertebrae (C1–C7)

The seven cervical vertebrae are the smallest of the vertebrae. They extend from the occipital bone of the skull to the thorax.

The first (C1), second (C2), and seventh (C7) cervical vertebrae possess unique characteristics and are considered to be atypical cervical vertebrae, while the third through the sixth (C3–C6) display similar characteristics and are considered to be typical cervical vertebrae.

1.1.3.1 Typical cervical vertebra (C3–C6)

The bodies of these four vertebrae are small and broader from side to side than from front to back.

- The anterior and posterior surfaces are flattened and of equal depth; the former is placed on a lower level than the latter, and its inferior border is prolonged downward, to overlap the upper and forepart of the vertebra below.
- The upper surface is concave transversely, and presents a projecting **lip** on either side.
- The lower surface is concave from front to back, convex from side to side, and presents laterally shallow concavities that receive the corresponding projecting lips of the underlying vertebra.

The pedicles are directed laterally and backward, and attach to the body midway between its upper and lower borders, so that the **superior vertebral notch is as deep as the inferior**, but it is, at the same time, **narrower**.

The laminae are narrow, and thinner above than below.

The vertebral foramen is large, and of **a triangular form**.

The spinous process is short and has a bifid **(Bifidus**, cut into two parts), the two divisions being often of unequal size.

The superior and inferior articular processes of cervical vertebrae have fused on either or both sides to form articular pillars, columns of bone that project laterally from the junction of the pedicle and lamina.

The articular facets are flat and of an oval form:

- The superior face backward, upward, and slightly medially.
- The inferior face forward, downward, and slightly laterally.

When cervical vertebrae C3–C7 articulate, their interlocking vertebral bodies permit a relatively greater degree of flexibility than do those of other regions.

The transverse processes are each pierced by **the foramen transversarium**, which, in the upper six vertebrae, gives passage to the vertebral artery and vein, as well as a plexus of sympathetic nerves. **Each process consists of an anterior and a posterior part**. These two parts are joined, outside the foramen, by a bar of bone that exhibits **a deep groove on its upper surface** for the passage of the corresponding spinal nerve.

The anterior portion is the rudiment of the rib and is named the costal process **(Processus costarius)** or costal element. It arises from the side of the body, is directed laterally in front of the foramen, and ends in **a tubercle, the anterior tubercle (Tuberculum anterius).**

The posterior part, the true transverse process **(Processus transversus),** springs from the vertebral arch behind the foramen, and is directed forward and laterally; it ends in a flattened **vertical tubercle, the posterior tubercle. (Tuberculum posterius).**

For excellent students: *The anterior tubercle of the* ***sixth cervical (C6)*** *vertebra is known as* ***the carotid tubercle*** *or Chassaignac tubercle. This separates the carotid artery from the vertebral artery and the carotid artery can be massaged against this tubercle to relieve the symptoms of supraventricular tachycardia. The carotid tubercle is also used as a landmark for anesthesia of the brachial plexus and cervical plexus.*

The cervical spinal nerves emerge from above the cervical vertebrae. For example, the cervical spinal nerve 3 (C3) passes above C3.

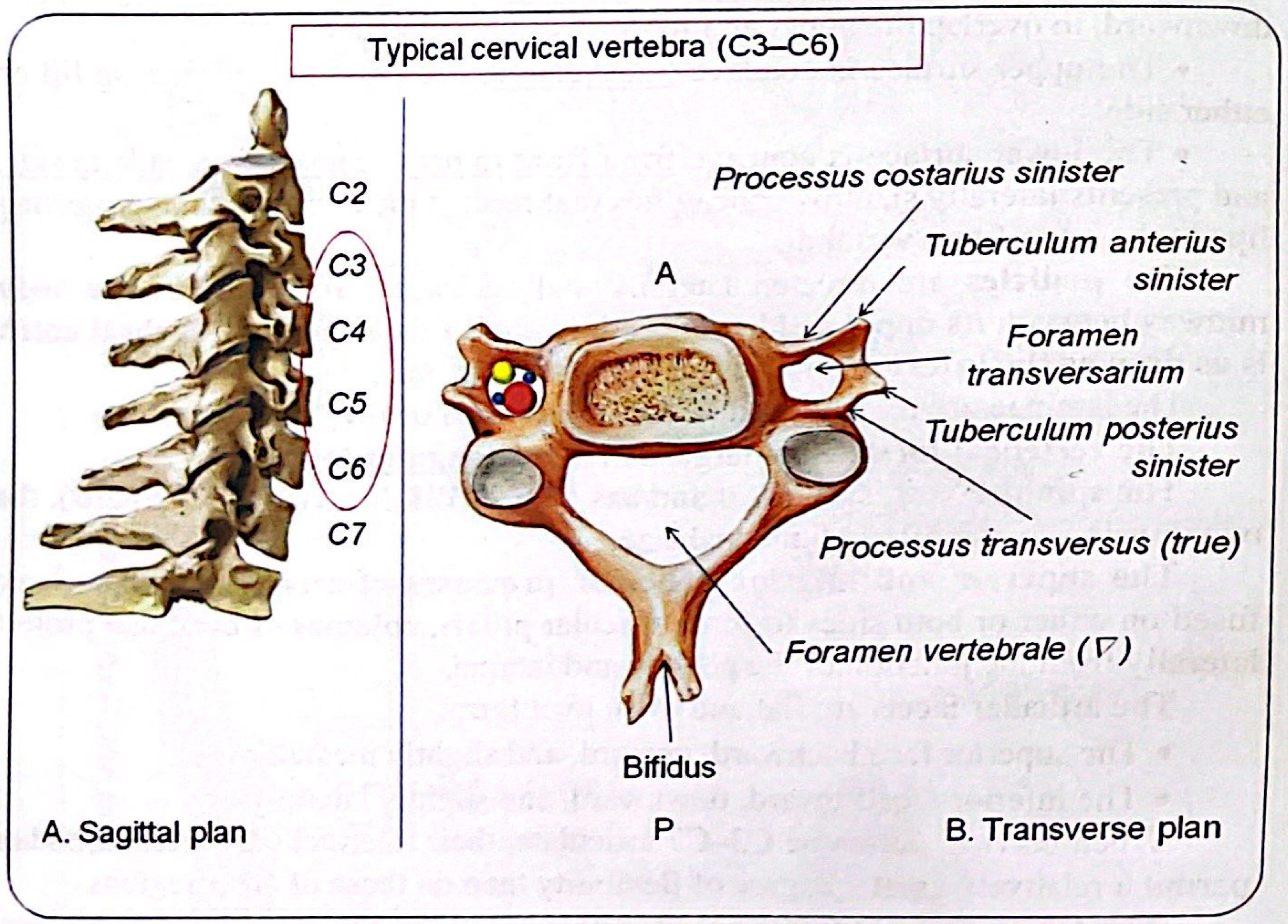

Typical cervical vertebra (C3–C6)
C2
C3
C4
C5
C6
C7
Processus costarius sinister
Tuberculum anterius sinister
A
Foramen transversarium
Tuberculum posterius sinister
Processus transversus (true)
Foramen vertebrale (∇)
Bifidus
P
A. Sagittal plan
B. Transverse plan

Fig. 6. Typical cervical vertebra (A. Sagittal plan, B. Transverse plan) (original fig.)

1.1.3.2. Atypical cervical vertebra

The Atlas (C1) can be distinguished from the other vertebrae by the following features: (1) the lack of a body; (2) the lack of a spinal process; (3) the possession of semicircular anterior and posterior vertebral arches **(Arcus anterior et posterior)** joined to one another by two mare developed lateral masses **(Massae laterales),** which carries the articular surfaces superior **(Fovea articularis superior)** for articulation with the cranium and inferior **(Fovea articularis inferior)** for articulation with C2; (4) The anterior arch contains anterior tuberculum on the anterior surface **(Tuberculum anterius)** and fossa for the dens of axis **(Fovea dentis)** on the posterior surface. The posterior arch bears the posterior tubercle **(Tuberculum posterius)** representing the spine; (5) the groove for the vertebral artery **(Sulcus arteriae vertebralis)** is on the superior surface of the arch; (6) the largest vertebral foramen of any vertebra.

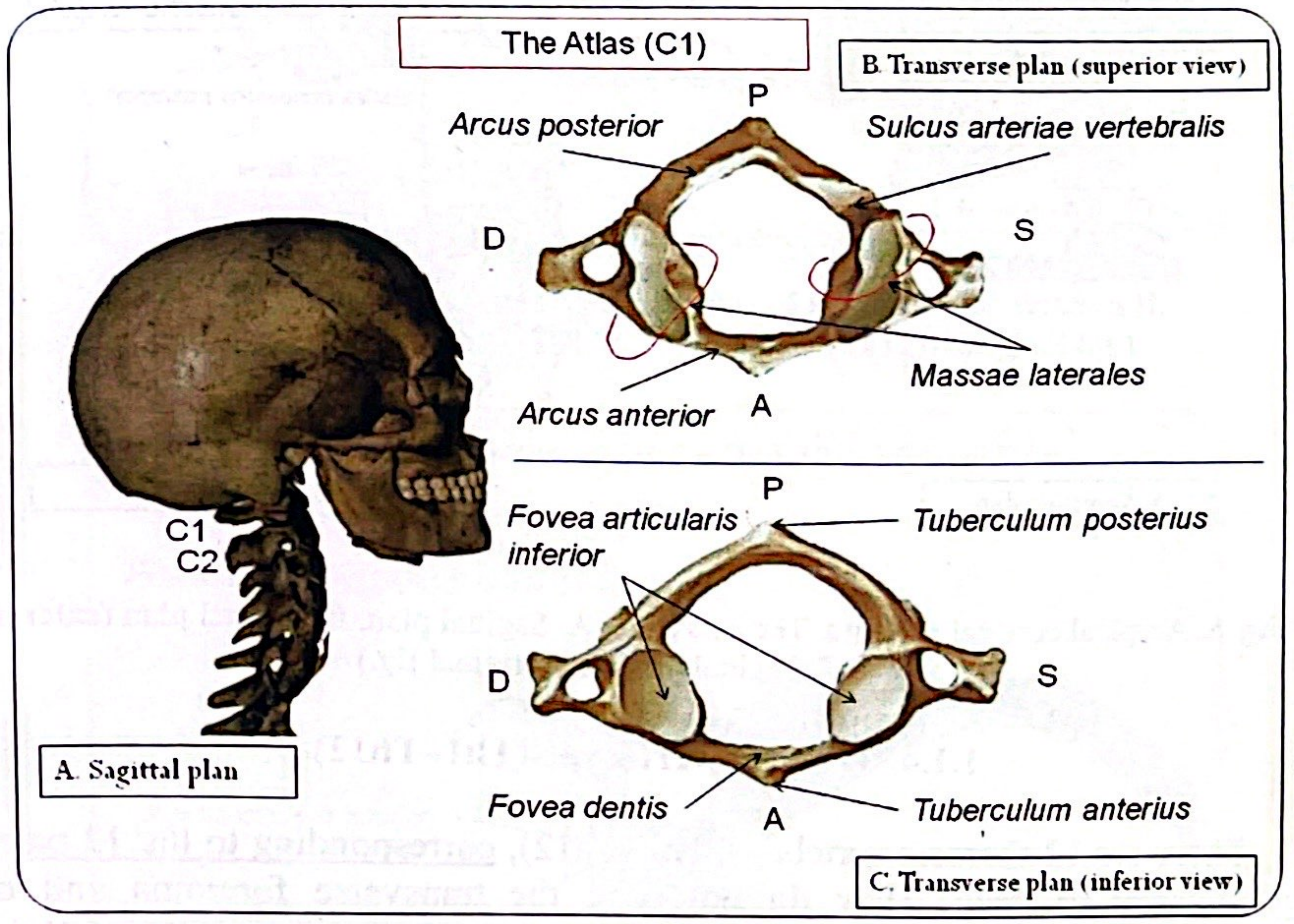


Fig. 7. Atypical cervical vertebra. Atlas (C1) (A. Sagittal plan, B. Transverse plan (superior view), C. Transverse plan (inferior view)) (original fig.)

The axis (C2) forms the pivot on which the atlas rotates. The most distinctive characteristic of this bone is the strong **odontoid process (Dens)** that rises perpendicularly from the upper surface of the body and articulates with fovea dentis of C1. The body is deeper in front than behind, and prolonged downward anteriorly to overlap the upper and front part of the third vertebra.

Vertebra Prominens (C7) has a distinctive long and prominent spinous process, which is palpable from the skin surface. It is not bifurcated.

The transverse foramen may be as large as that in the other cervical vertebrae, but is generally smaller on one or both sides; sometimes it is absent.

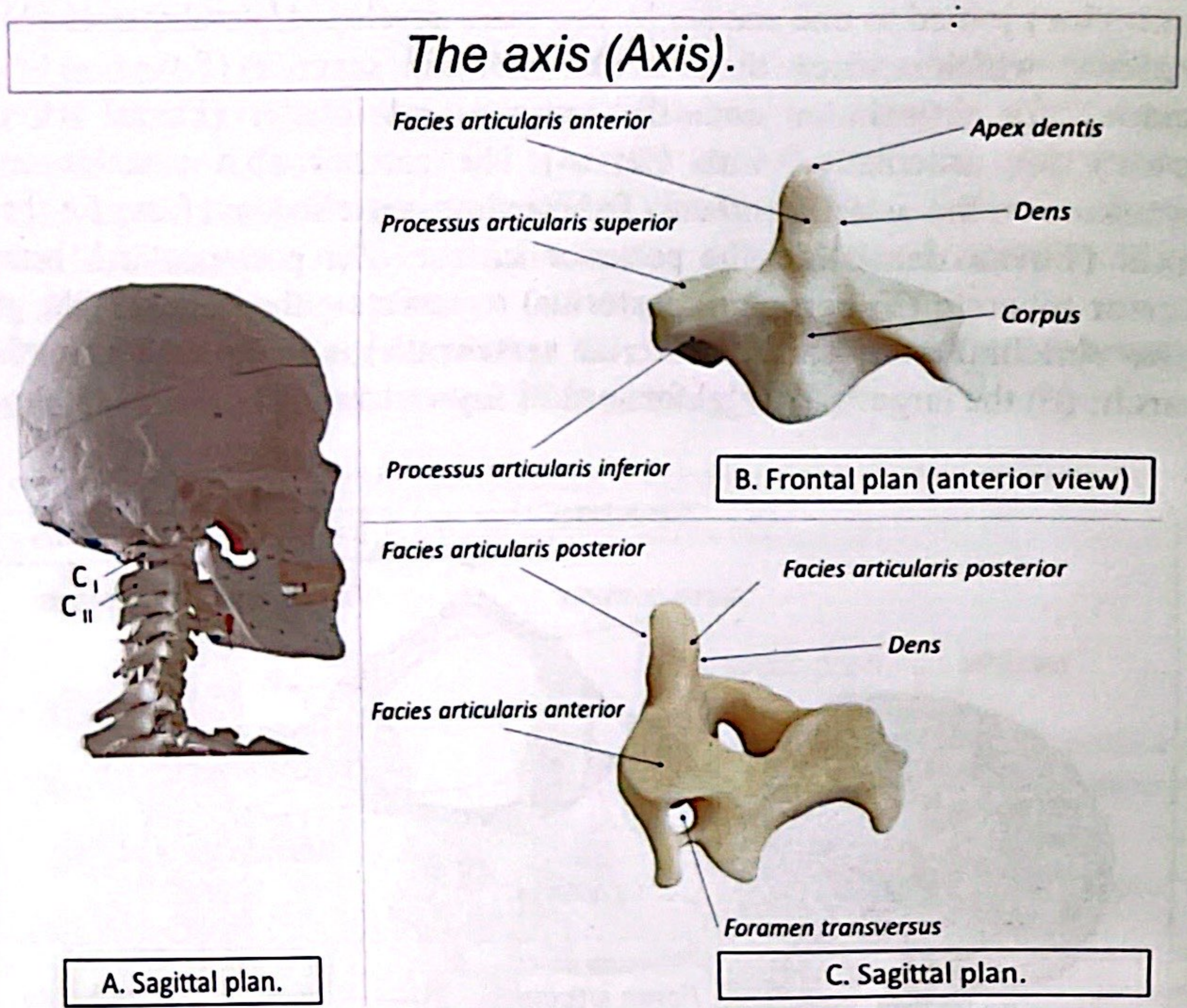

The axis (Axis).
Facies articularis anterior
Apex dentis
Processus articularis superior
Dens
Corpus
Processus articularis inferior
B. Frontal plan (anterior view)
C I
C II
Facies articularis posterior
Facies articularis posterior
Dens
Facies articularis anterior
Foramen transversus
A. Sagittal plan.
C. Sagittal plan.

Fig. 8. Atypical cervical vertebra. The axis (C2) (A. Sagittal plan, B. Frontal plan (anterior view), C. Sagittal plan C2) (original fig.)

1.1.4. Thoracic vertebrae (Th1–Th12)

There are 12 thoracic vertebrae (Th1–Th12), corresponding to the 12 pairs of ribs attached to them. They do not have the transverse foramina and bifid processes that distinguish the cervical vertebra, but possess the following distinctive features of their own:

- o The body is somewhat heart-shaped, more massive than in the cervical vertebrae but less than in the lumbar vertebrae.
- o The body of:
  - ➤ **Th1** has **1 costal facets (Foveae costalis)** for the 1st rib and **1 lower costal facets (Fovea costalis inferior)** for 2nd rib.
  - ➤ **Th2–Th10** has 2 small, smooth, slightly concave spots called **upper and lower costal facets (Fovea costalis superior et inferior)** for attachment of the ribs.

  - ➤ **Th11 – Th12** has **1** small, smooth, slightly concave **costal facets (Fovea costalis)** for the 11th and 12th rib respectively.

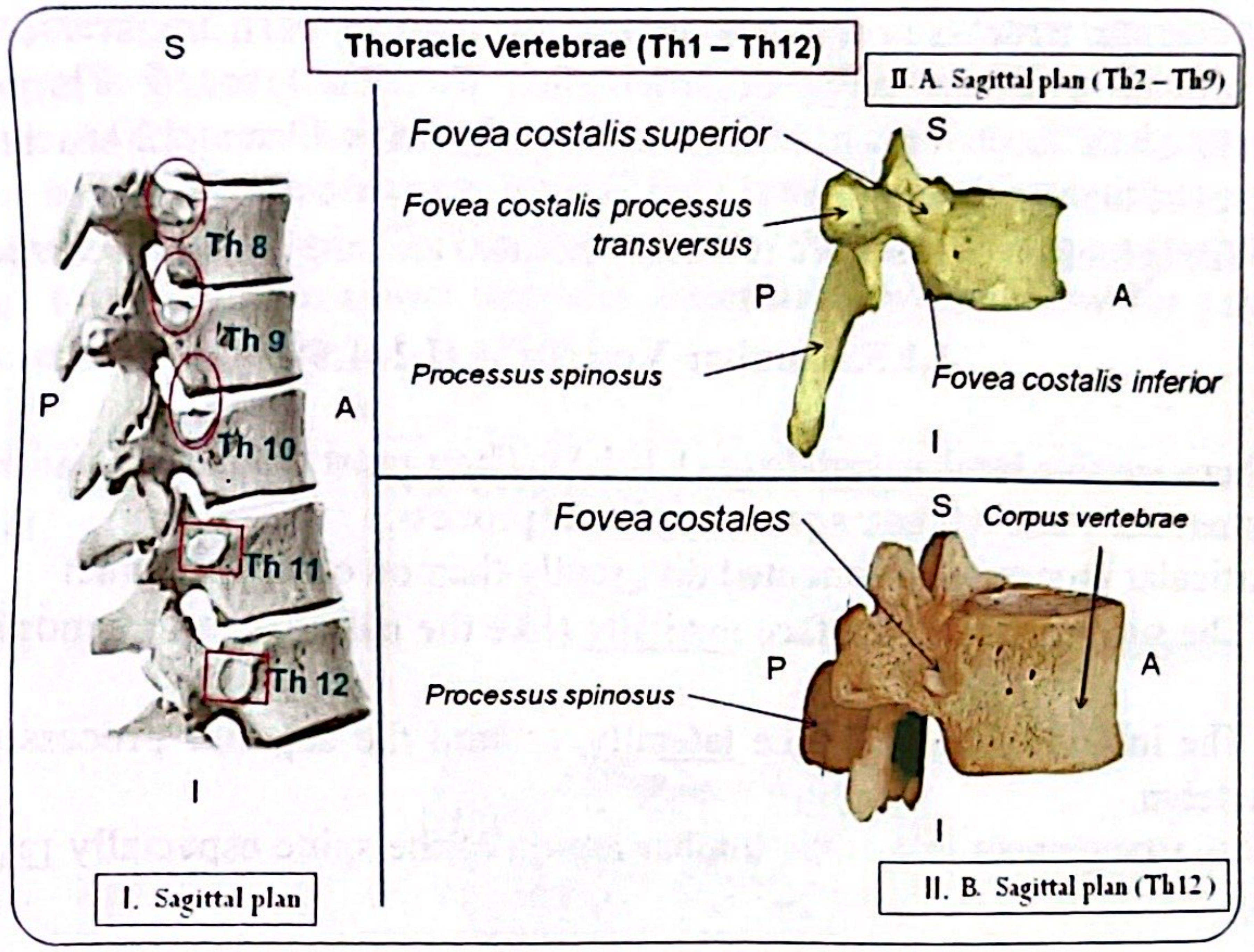


Fig. 9. Thoracic vertebrae (I. Sagittal plan of the transverse vertebra II. A. Sagittal plan (Th2–Th9), B. Sagittal plan (Th12)) (original fig.)

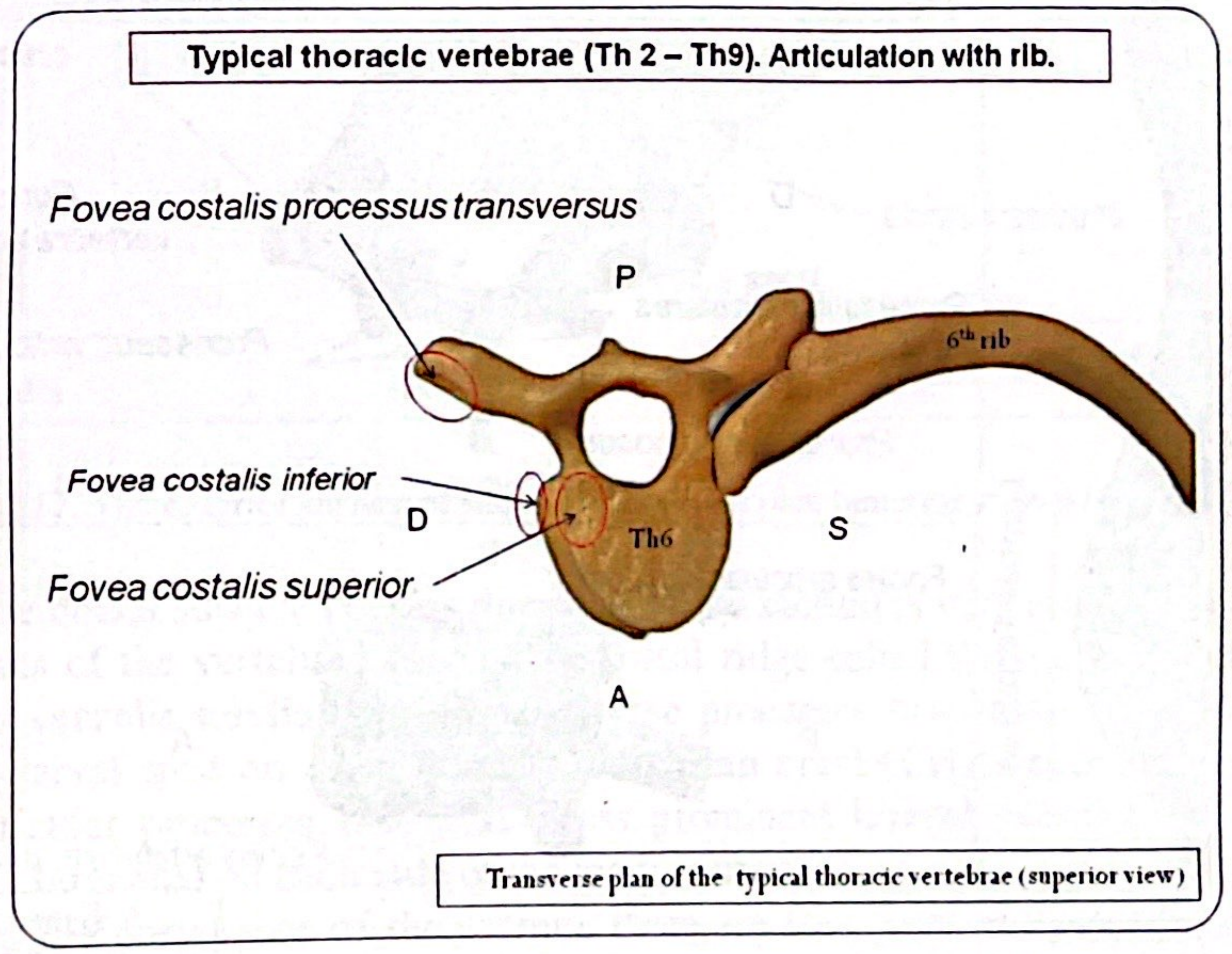

Typical thoracic vertebrae (Th 2 – Th9). Articulation with rib.
Fovea costalis processus transversus
P
6th rib
Fovea costalis inferior
D
Th6
S
Fovea costalis superior
A
Transverse plan of the typical thoracic vertebrae (superior view)

Fig. 10. Typical thoracic vertebrae. Articulation with rib. (Transverse plan, superior view) (original fig.)

A rib articulates with the inferior costal facet of the upper vertebra and the superior costal facet of the vertebra below that (first point of articulation for ribs).

- Vertebrae Th1 to Th10 have a shallow, cuplike **transverse costal facet (Fovea costalis processus transversus)** at the end of each transverse process. These provide a second point of articulation for ribs 1 to 10. There are no transverse costal facets on Th11 and Th12 because ribs 11 and 12 attach only to the bodies of the vertebrae.
- The spinous processes are relatively pointed and angle sharply downward.

1.1.5. Lumbar Vertebrae (L1–L5)

There are five lumbar vertebrae (L1–L5). Their most distinctive features are a thick, stout body and a blunt, squarish spinous process.

Articular processes are oriented differently than on other vertebrae:

- The superior processes face medially (like the palms of your hands about to clap).
- The inferior processes face laterally, toward the superior processes of the next vertebra.

This arrangement makes the lumbar region of the spine especially resistant to twisting.

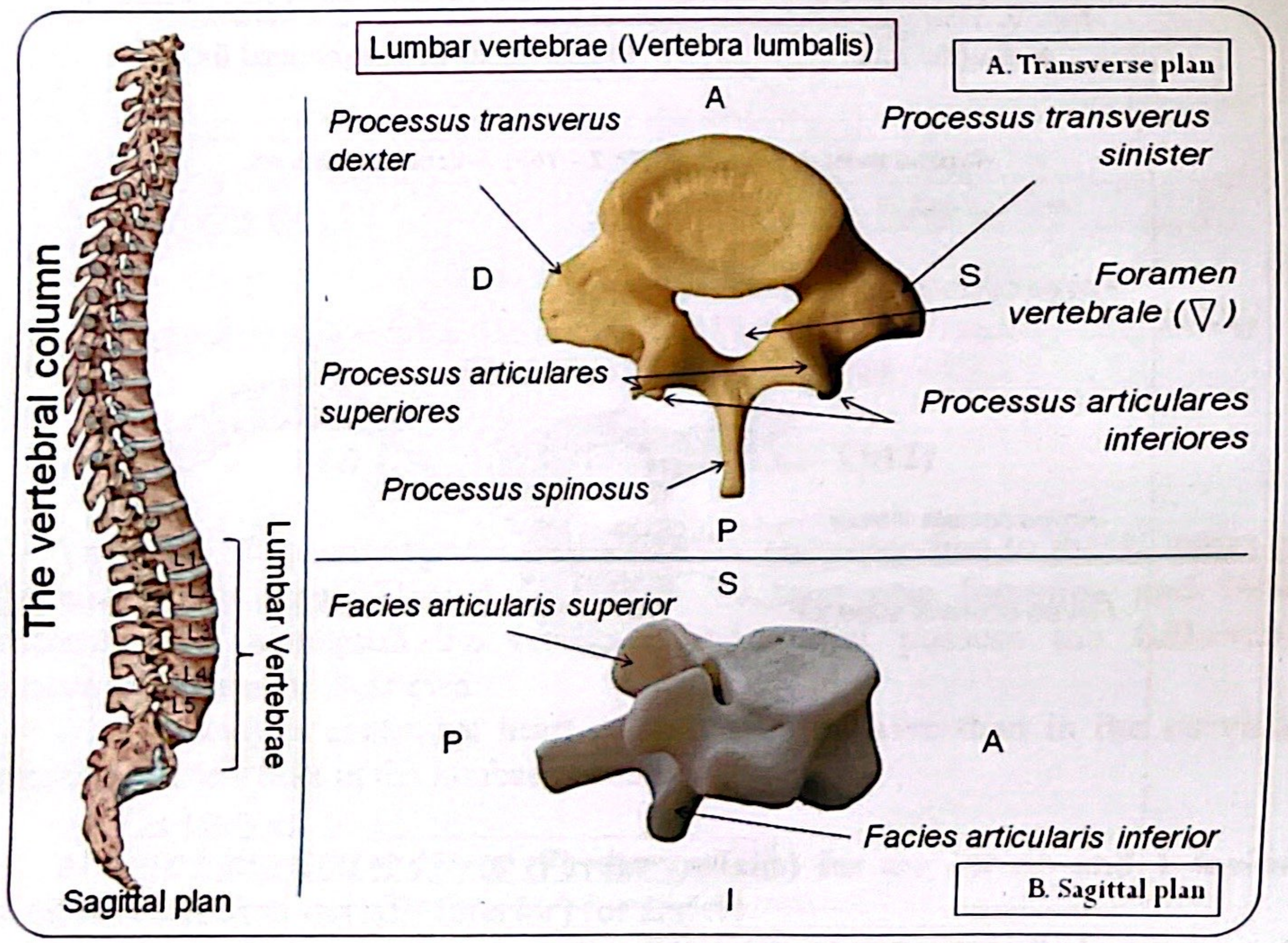

Lumbar vertebrae (Vertebra lumbalis)
A. Transverse plan
A
Processus transverus dexter
Processus transverus sinister
D
S
Foramen vertebrale (∇)
Processus articulares superiores
Processus articulares inferiores
Processus spinosus
P
S
Facies articularis superior
P
A
Facies articularis inferior
I
B. Sagittal plan
The vertebral column
Lumbar Vertebrae
Sagittal plan

Fig. 11. Lumbar vertebrae (A. Transverse plan (superior view), B. Sagittal plan)) (original fig.)

1.1.6. Sacrum (Os sacrum)

The sacrum is a bony plate that forms the dorsal wall of the pelvic cavity. In children, there are five separate sacral vertebrae (S1–S5) **(vertebrae sacrales)**. They begin to fuse around age 16 and are fully fused by age 26.

The anterior surface (Facies pelvica) of the sacrum is relatively smooth and concave and has four **transverse lines (Linea transversae)** that indicate where the five vertebrae have fused. This surface exhibits four pairs of large **anterior sacral (pelvic) foramina (Foramina sacralia anteriora)**, which allow for passage of nerves and arteries to the pelvic organs.

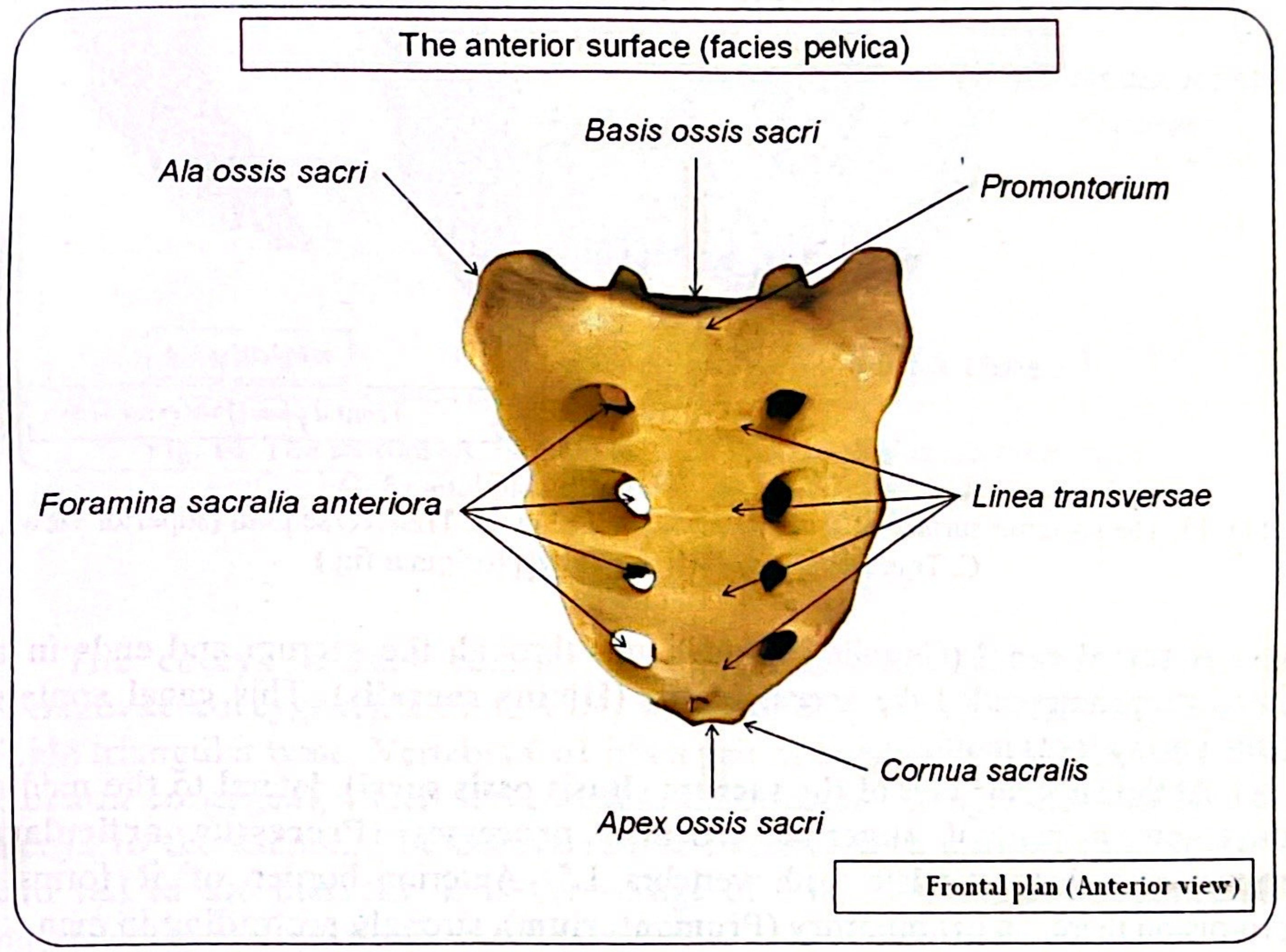

The anterior surface (facies pelvica)
Basis ossis sacri
Ala ossis sacri
Promontorium
Foramina sacralia anteriora
Linea transversae
Cornua sacralis
Apex ossis sacri
Frontal plan (Anterior view)

Fig. 12. The anterior surface of sacrum (A. Frontal plan (anterior view)) (original fig.)

The dorsal surface **(Facies dorsalis)** of the sacrum is very rough. The spinous processes of the vertebrae fuse into a dorsal ridge called the median sacral crest **(Crista sacralis mediana)**. The transverse processes fuse into a less prominent medial sacral crest on each side of **the median crest (Crista sacralis medialis)**. The articular processes fuse into a less prominent **lateral sacral crest (Crista sacralis lateralis)** on each side of the median crest.

On the dorsal side of the sacrum, there are four pairs of openings for spinal nerves, **the posterior sacral foramina (Foramina sacralia posteriora)**. The nerves that emerge here supply the gluteal region and lower limb.

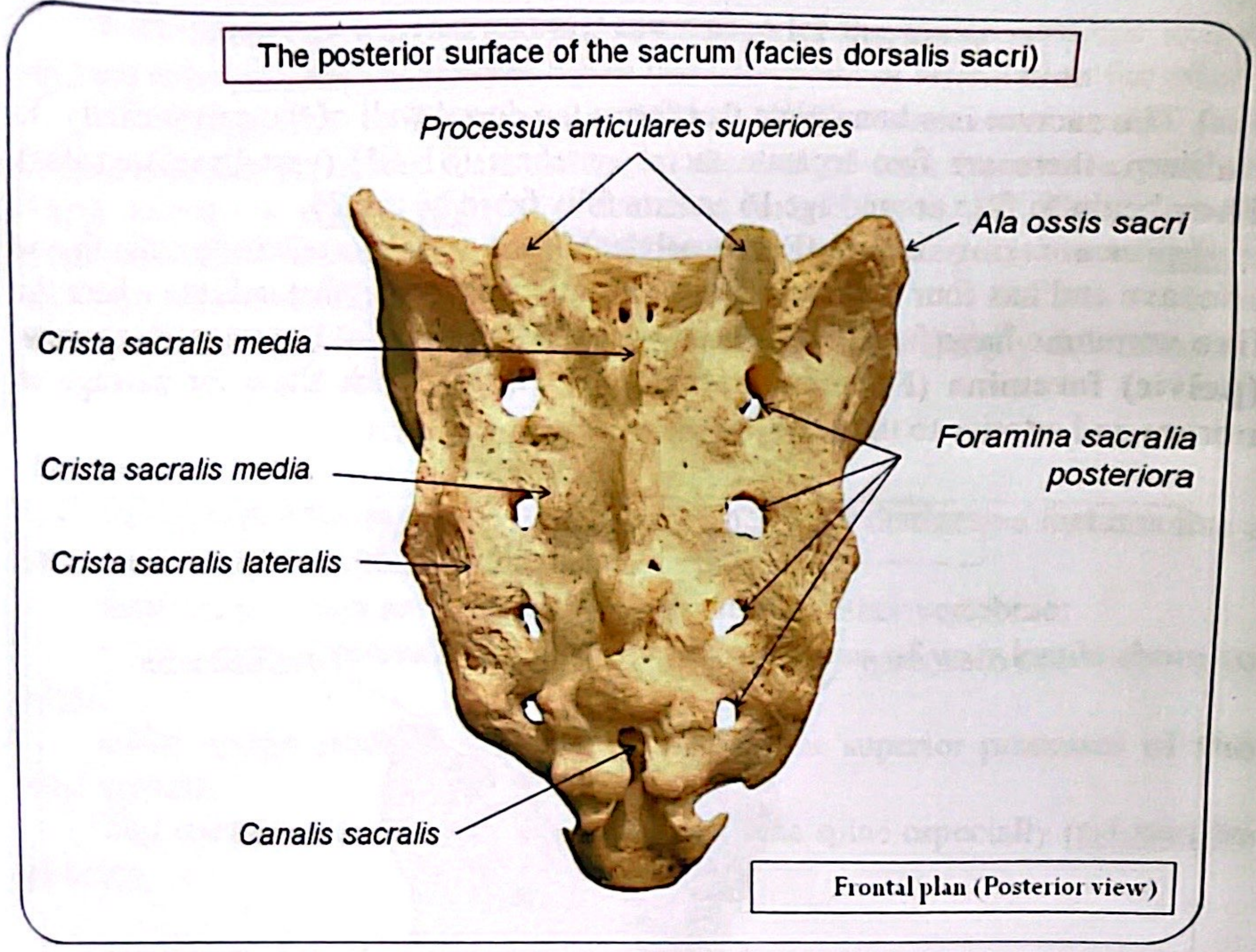

The posterior surface of the sacrum (facies dorsalis sacri)
Processus articulares superiores
Ala ossis sacri
Crista sacralis media
Crista sacralis media
Foramina sacralia posteriora
Crista sacralis lateralis
Canalis sacralis
Frontal plan (Posterior view)

Fig. 13. The posterior surface of sacrum (A. Sagittal plan, B. Transverse plan (superior view), C. Transverse plan (inferior view)) (original fig.)

A sacral canal (Canalis sacralis) runs through the sacrum and ends in an inferior opening called the **sacral hiatus (Hiatus sacralis)**. This canal contains spinal nerve roots in life.

At the **superior end of the sacrum (Basis ossis sacri)**, lateral to the median crest, are a pair of **superior articular processes (Processus articulares superiores)** that articulate with vertebra L5. Anterior border of it forms a protrusion there – **a promontory (Promontorium),** strongly protruding in men

Lateral to these are **a pair of large Facies auricularis**, rough, wing like extensions called the alae **(Ala ossis sacri)**, which have the – facies auricularis, that articulate with a similarly shaped surface on the hip bone (**Os coxae**) and forms the strong, nearly immovable sacroiliac joint.

The inferior end of the sacrum **(Apex ossis sacri)** – narrow, blunt, has a small oval articular surface to connect with the upper surface of the sacrococcygeal joint. The tubercles which represent the inferior articular processes of the fifth sacral vertebra are prolonged downward as rounded processes – **the sacral horns (Cornua sacralis),** and are connected to the cornua of the coccyx.

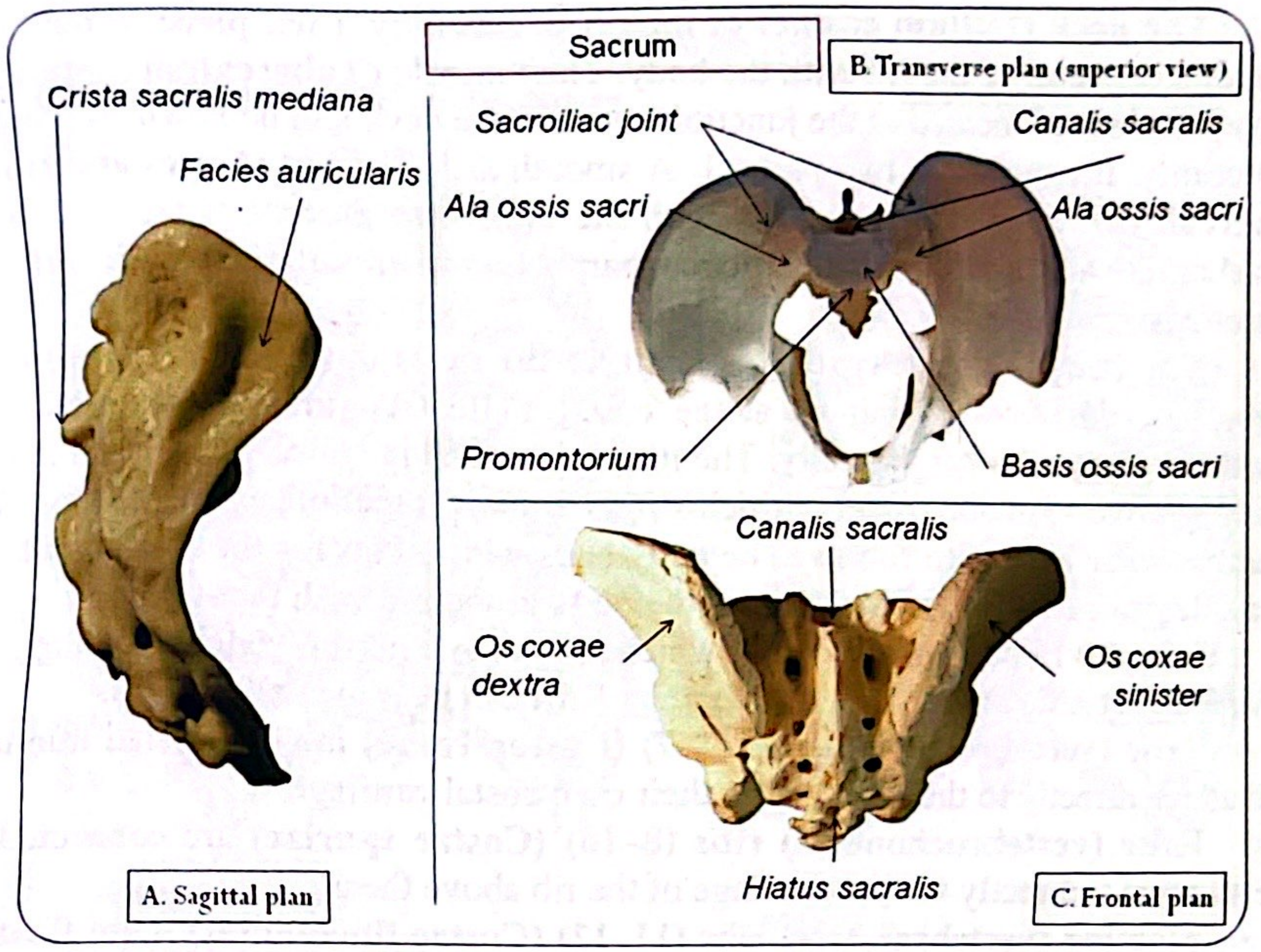


Fig. 14. The sacrum (A. Sagittal plan, B. Transverse plan (superior view), C. Frontal plan (posterior view)) (original fig.)

1.1.7. Coccyx (Os coccyx)

The coccyx usually consists of four (sometimes five) small vertebrae **(Vertebrae coccygeae)**, Co1 to Co4, which fuse by the age of 20 to 30 into a single triangular bone. Vertebra Co1 has a pair of hornlike projections, the cornua **(Cornua coccygea)**, which serve as attachment points for ligaments that bind the coccyx to the sacrum. The coccyx can be fractured by a difficult childbirth or a hard fall to the buttocks. It is the vestige of a tail; it provides attachment for muscles of the pelvic floor.

1.2. Anatomy of the ribs

The ribs (Costae) are narrow, curved, flat bones which are symmetrically located on the sides of the thoracic region of the vertebral column. Ribs are distinguished by:

- **The head (Caput costae)** is wedge shaped and has two articular facets **(Facies articularis capitis costae superior et inferior)**. The crest of the head **(Crista capitis costae)** lies horizontally and separates the articular facets (into superior and inferior). The larger of the two facets is for articulation with the superior costal facet of its corresponding vertebral body, while the smaller of the two articulates with the inferior costal facet on the body of the superior vertebra.

- **The neck (Collum costae)** of the rib is generally a flat piece of bone that connects the head of the rib with the body. The tubercle **(Tuberculum costae)** is a bony prominence located at the junction between the neck and body which projects posteriorly. It consists of two parts: 1. A smooth articular part **(Facies articularis tuberculi costae)** which articulates with the transverse process of the associated vertebra. 2. A roughened non articular part which forms the attachment of the costotransverse ligament.
- **The body (Corpus costae)** or shaft, of the rib is thin, flat and curved. The curve becomes most prominent at the costal angle **(Angulus costae)**, which is when the rib turns anterolaterally. The internal surface is concave and contains the costal groove **(Sulcus costae)** which offers some protection and a path for the neurovascular bundle to follow. The body ends with a cup for the costal cartilage **(Cartilagines costales)**, which allows the rib to articulate with the sternum.

There are 12 pairs of ribs, all of which articulate with the vertebral column, 7 have a direct articulation with the sternum. Ribs can be allocated to types:

- **True (vertebrosternal) ribs (1–7) (Costae verae)** are considered true ribs and attach directly to the sternum via their own costal cartilage.
- **False (vertebrochondral) ribs (8–10) (Costae spuriae)** are connected to the sternum indirectly via the cartilage of the rib above them.
- **Floating (vertebral, free) ribs (11–12) (Costae fluctuantes)** – are floating ribs and the cartilage of these ribs tends to end within the abdominal musculature.

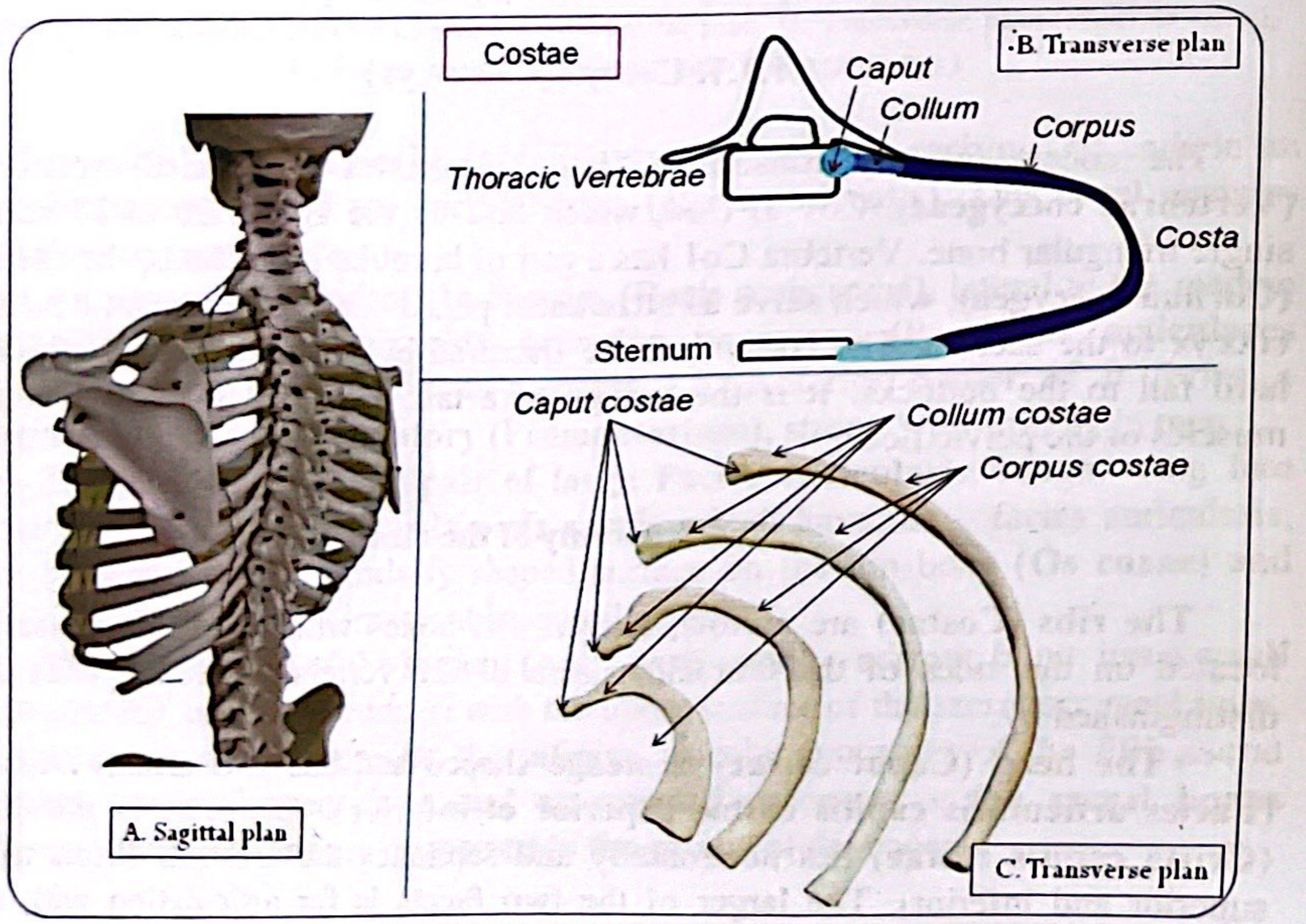


Fig. 15. The ribs (Costae) (A. Sagittal plan, B. Transverse plan (scheme), C. Transverse plan (superior view)) (original fig.)

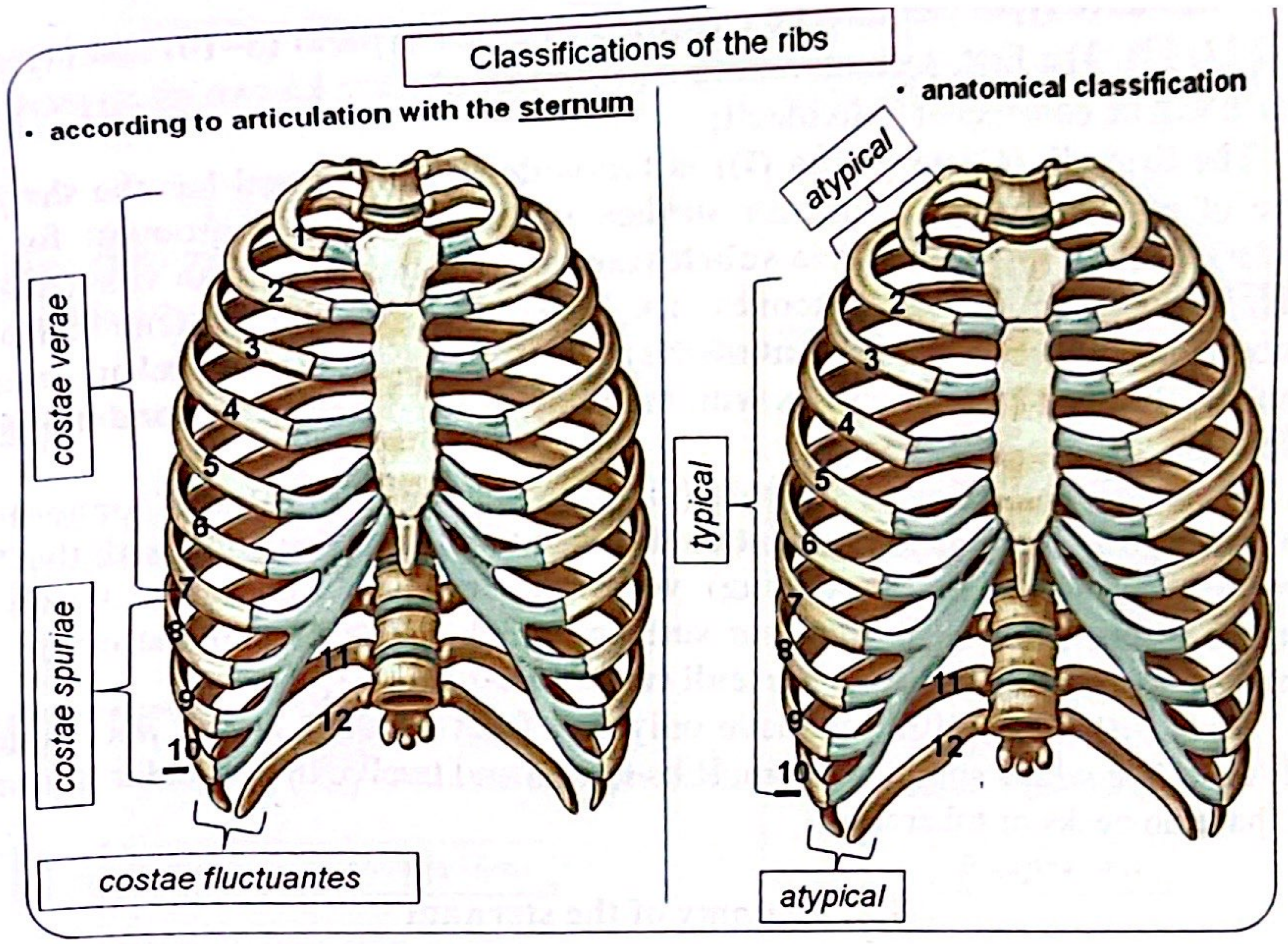

Classifications of the ribs
• according to articulation with the sternum
• anatomical classification
atypical
costae verae
typical
costae spuriae
costae fluctuantes
atypical
1
2
3
4
5
6
7
8
9
10
11
12

Fig. 16. Classifications of the ribs (original fig.)

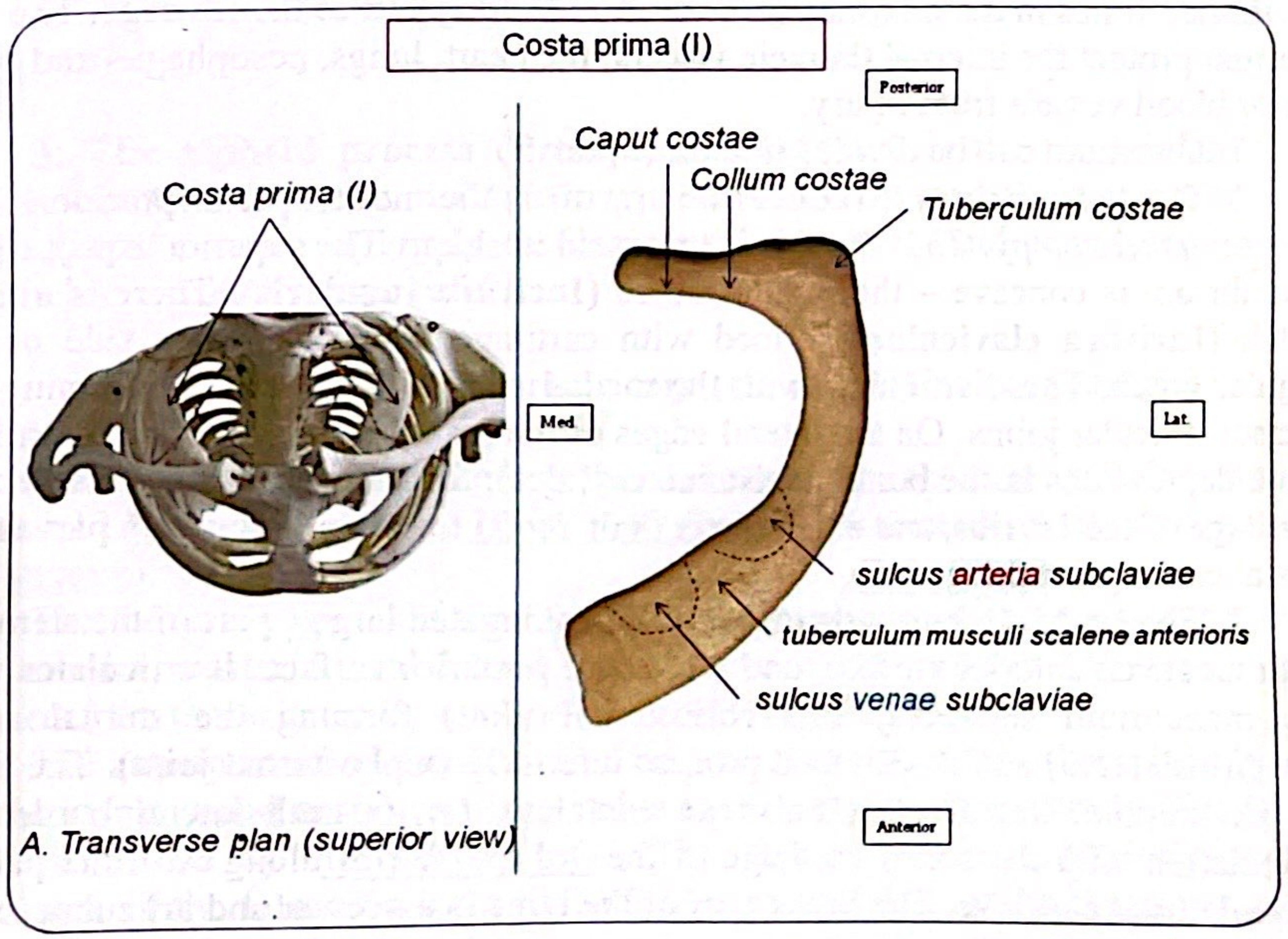


Fig. 17. The first rib (Costa prima (I)) (original fig.)

These three types can then be classified as either **typical (3–10)** and **atypical (1, 2, 11, 12)**. The first, second, eleven and twelfth ribs are known as atypical and as such will be considered individually.

The first rib (Costa prima (I)) is the widest, shortest and has the sharpest curve of all the ribs. The superior surface is marked by two grooves: for the subclavian artery (**Sulcus arteria subclaviae**) and for the subclavian vein (**Sulcus venae subclaviae**). These grooves are separated by the scalene tubercle (**Tuberculum musculi scalene anterioris**) – to which the anterior scalene muscle attaches. The head only articulates with the body of the Th1 vertebra and only one articulatory surface is present.

The second rib (Costae secunda (II)) is thinner and significantly longer than the first. There are two facets present on the head to allow articulation with the Th1 (superior) and Th 2 (corresponding) vertebrae. Its main unusual feature is a roughened tuberosity on its superior surface, which forms part of the origin for serratus posterior (**Tuberositas musculi serrati posterioris**).

The tenth to twelfth ribs have only one facet on their heads, and as such only articulate with a single vertebra. Ribs eleven and twelve in particular are short and have no necks or tubercles.

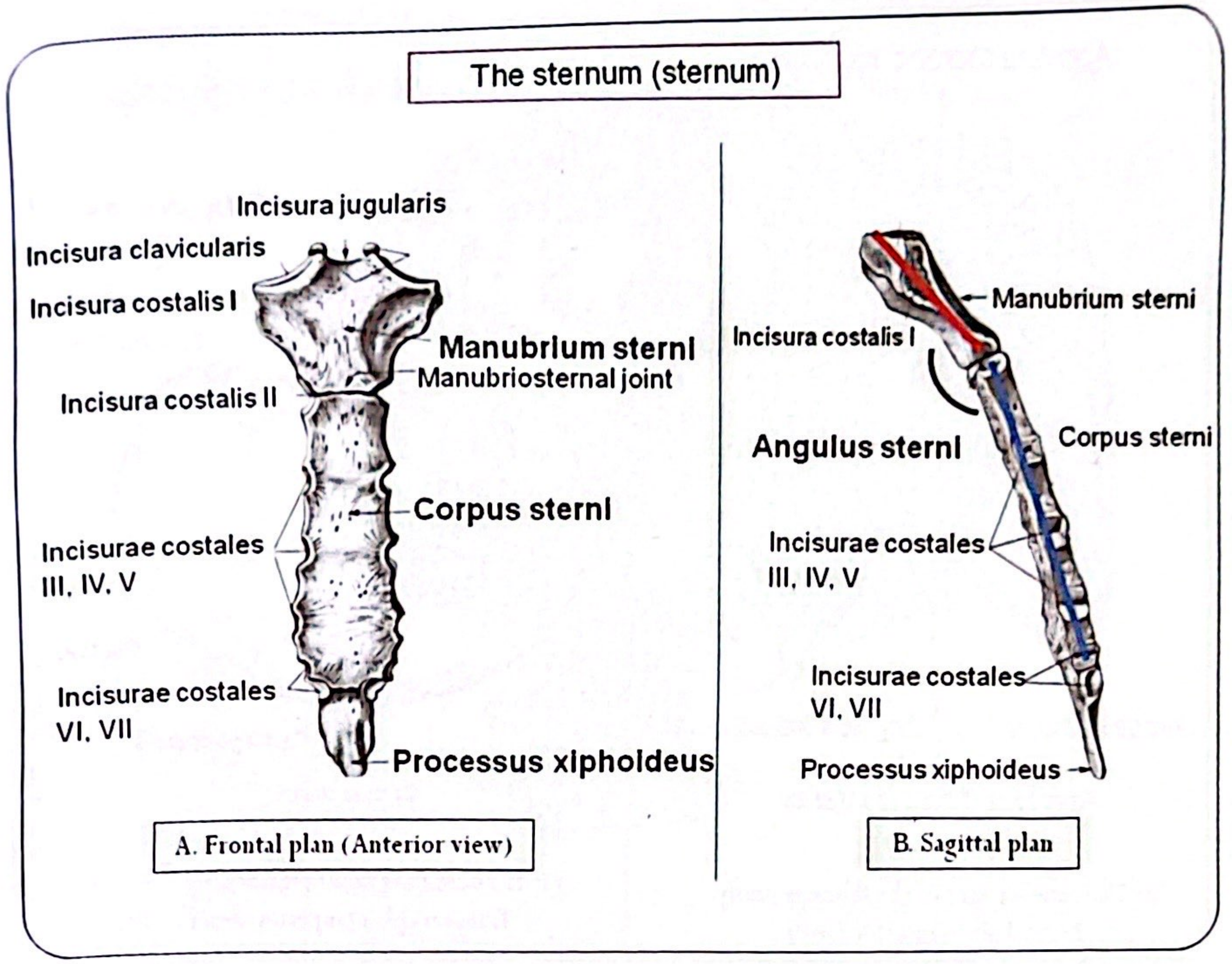
1.3. Anatomy of the sternum

The sternum (or breastbone) is a flat bone located at the **anterior aspect** of the thorax. It lies in the midline of the chest and forms part of the rib cage. The sternum protect the internal thoracic viscera: the heart, lungs, oesophagus and major blood vessels from injury.

The sternum can be divided into three parts:

1. The manubrium (Manubrium sterni) is the most superior portion of the sternum *(skeletotopy: Th3–Th4)*. It is trapezoid in shape. The superior aspect of the manubrium is concave – the jugular notch (**Incisura jugularis**). There is a large notch (**Incisura clavicularis**), lined with cartilage from the either side of the jugular notch. These articulate with the medial ends of the clavicles, forming the sternoclavicular joints. On the lateral edges of the manubrium, there are a cartilage lined depressions in the bone (**Incisurae costales**), for articulations with the costal cartilage of the 1st ribs, and a demifacet (half-facet) for articulation with part of the costal cartilage of the 2nd rib.

2. The body (Corpus sterni) is flat and elongated largest part of the sternum, with a convex anterior surface, and a concave posterior surface. It articulates with the manubrium superiorly (manubriosternal joint) forming the sternal angle (**Angulus sterni**) and the xiphoid process inferiorly (xiphosternal joint)**.** The body of the sternum has facets (**Incisurae costales**), on its each lateral border for articulation with the costal cartilage of the 3rd to 7th ribs along with the part of second costal cartilage. The lower part of the bone is narrower and articulates with the xiphoid process.



A. Frontal plan (Anterior view)

B. Sagittal plan

Fig. 18. The sternum (original fig.)

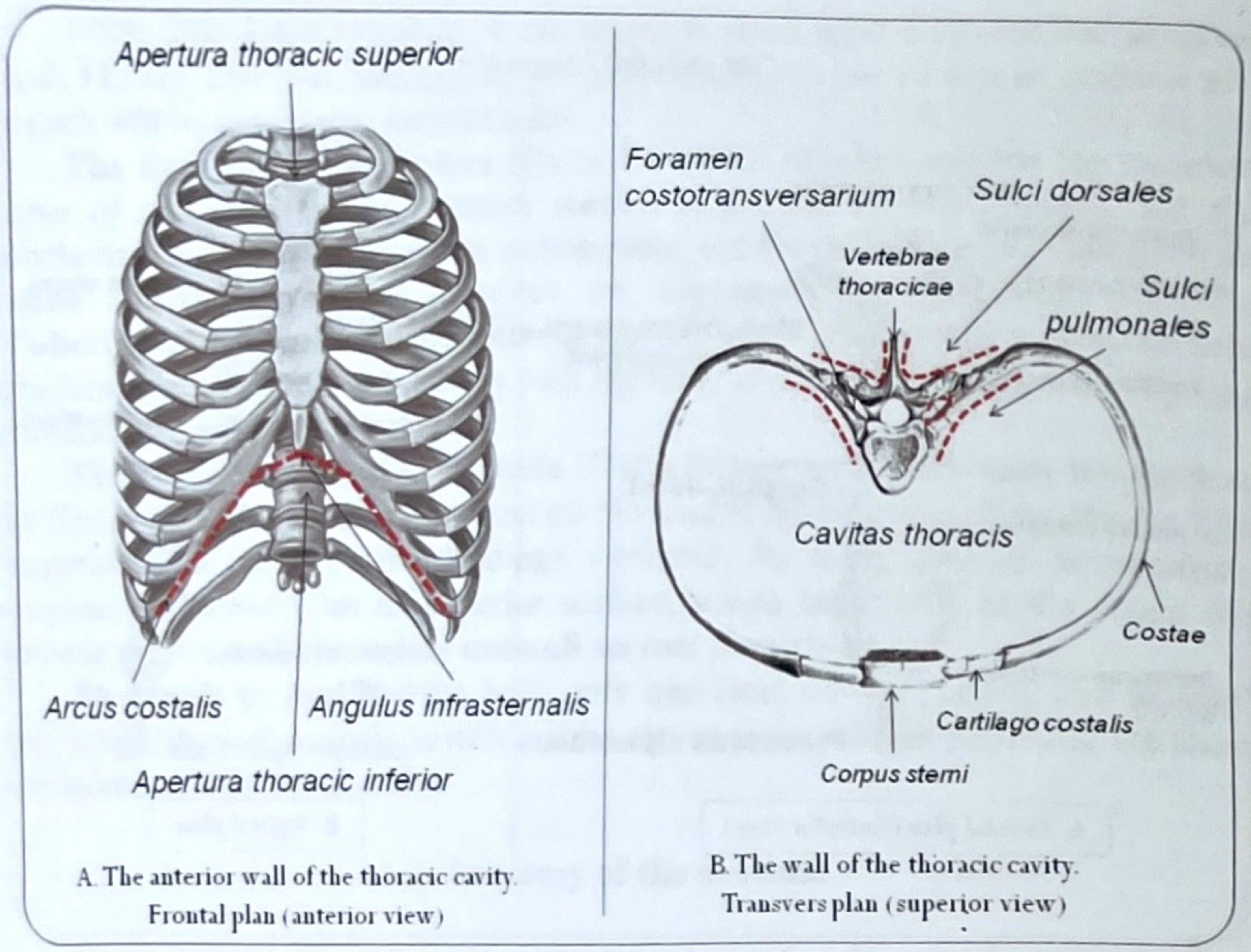
3. The xiphoid process (Processus xiphoideus) is the most inferior and smallest part of the sternum *(skeletotopy: Th10)* and is variable in shape and size The xiphoid process is largely cartilaginous in structure, and completely ossifies late in life – around the age of 40.

1.4. Anatomy of the thoracic cage (rib cage) (Cavitas thoracis)

The thoracic cage (rib cage) is the skeleton of the thoracic wall. It is formed by the 12 thoracic vertebrae, 12 pairs of ribs and associated costal cartilages and the sternum.

The thoracic cage takes the form of a truncated cone. On thoracic cage, there are anterior, posterior and lateral walls, superior and inferior foramens, which surround the thoracic cavity or chest cavity (**Cavitas thoracis**).

The anterior wall of the thoracic cavity is shorter than the others; it is formed by the sternum and costal cartilage and is located obliquely anteriorly. The lateral wall is formed by the corpus costae. The xiphoid process (anteriorly), costal cartilages of the false ribs form rib arch (**Arcus costalis**) and in the upper part it named – **Angulus infrasternalis.**



A. The anterior wall of the thoracic cavity. Frontal plan (anterior view)

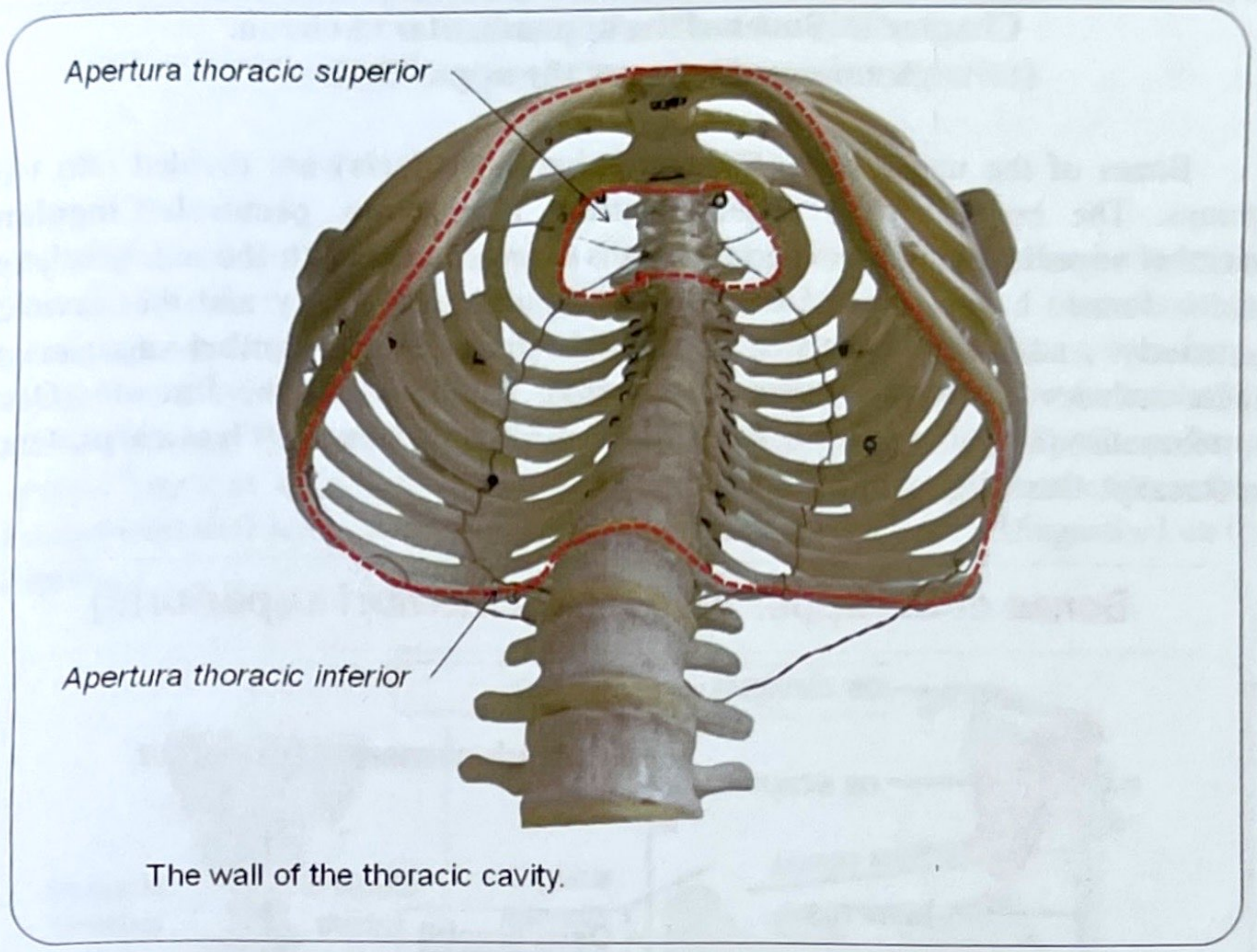
B. The wall of the thoracic cavity. Transvers plan (superior view)

Fig. 19. The wall of the thoracic cavity (original fig.)

The posterior wall of the thoracic cavity is formed by 12 thoracic vertebrae and part from the head to the angle of 12 pairs of ribs. On the outer surface of the posterior wall (between the spinous processes of the vertebrae and the corners of the ribs) there are two grooves – **Sulci dorsales**, for deep back muscles. **Foramen costotransversarium** is located between the posterior surface of the collum costae and the anterior surface of the transvers process of the vertebra. On the inner surface of the posterior wall (between the body of the vertebrae and the corners of the ribs) there are located lung's grooves **(Sulci pulmonales)**, for the vertebral part of the lung.

The thorax has two major openings:

- The superior thoracic aperture (**Apertura thoracic superior**) found superiorly. It opens towards the neck. It is bounded by: manubrium of sternum, the first pair of ribs, and the body of the vertebra Th1.
- The inferior thoracic aperture (**Apertura thoracic inferior**) is almost completely covered by the diaphragm, separating it from the abdominal cavity. It is bounded by: xiphoid process (anteriorly), costal cartilages, body 12th rib, body of 12th thoracic vertebrae.



The wall of the thoracic cavity.

Fig. 20 The wall of the thoracic cavity (original fig.)

Chapter II. Bones of the appendicular skeleton.
Anatomy of bones of the upper limb

Bones of the upper limb (**Ossa membri superioris**) are divided into two groups. The bones of the shoulder girdle (**Cingulum pectorale/Cingulum membri superior**) which connect the arms on each side with the axial skeleton and is formed by two sets of bones: the scapulae, posteriorly and the clavicles anteriorly. And bones of the free upper limb (**Pars libera membri superioris);** these includes bones of the arm (**Humerus**), the bones of the forearm (**Ossa antebrachii**) (**Ulna, Radius**), bones of the hand (**Ossa manus**) (**Ossa carpi, Ossa metacarpi, Ossa digitorum (Phalanges)**).

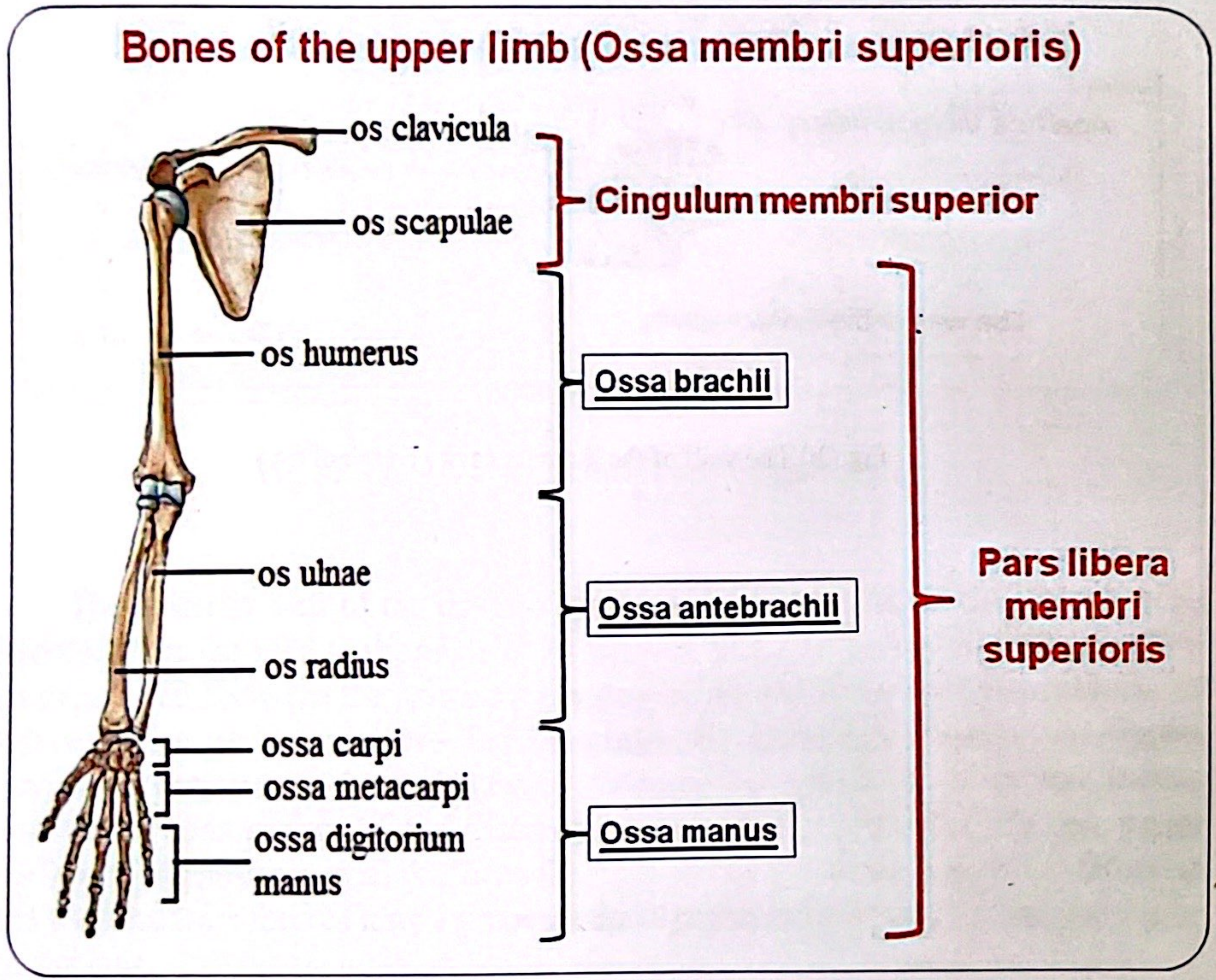


Fig. 21. The classification of bones of the upper limb (original fig.)

2.1. Bones of the shoulder girdle (cingulum pectorale/cingulum membri superior)

2.1.1. The scapula (Scapula)

The shoulder blade or scapula (**Scapula**) is a flat, triangular bone which articulates with the humerus at the glenohumeral join and the clavicle at the acromioclavicular joint. Also it serves as a site for attachment for many muscles.

It has three borders: upper (**Margo superior**), medial (**Margo medialis**), lateral (**Margo lateralis**) and three corners: upper (**Angulus superior**), lower corner (**Angulus inferior**), lateral (**Angulus lateralis**). Costal or anterior surface (**Facies costalis**) and posterior surface (**Facies posterior**) are distinguished on the scapula.

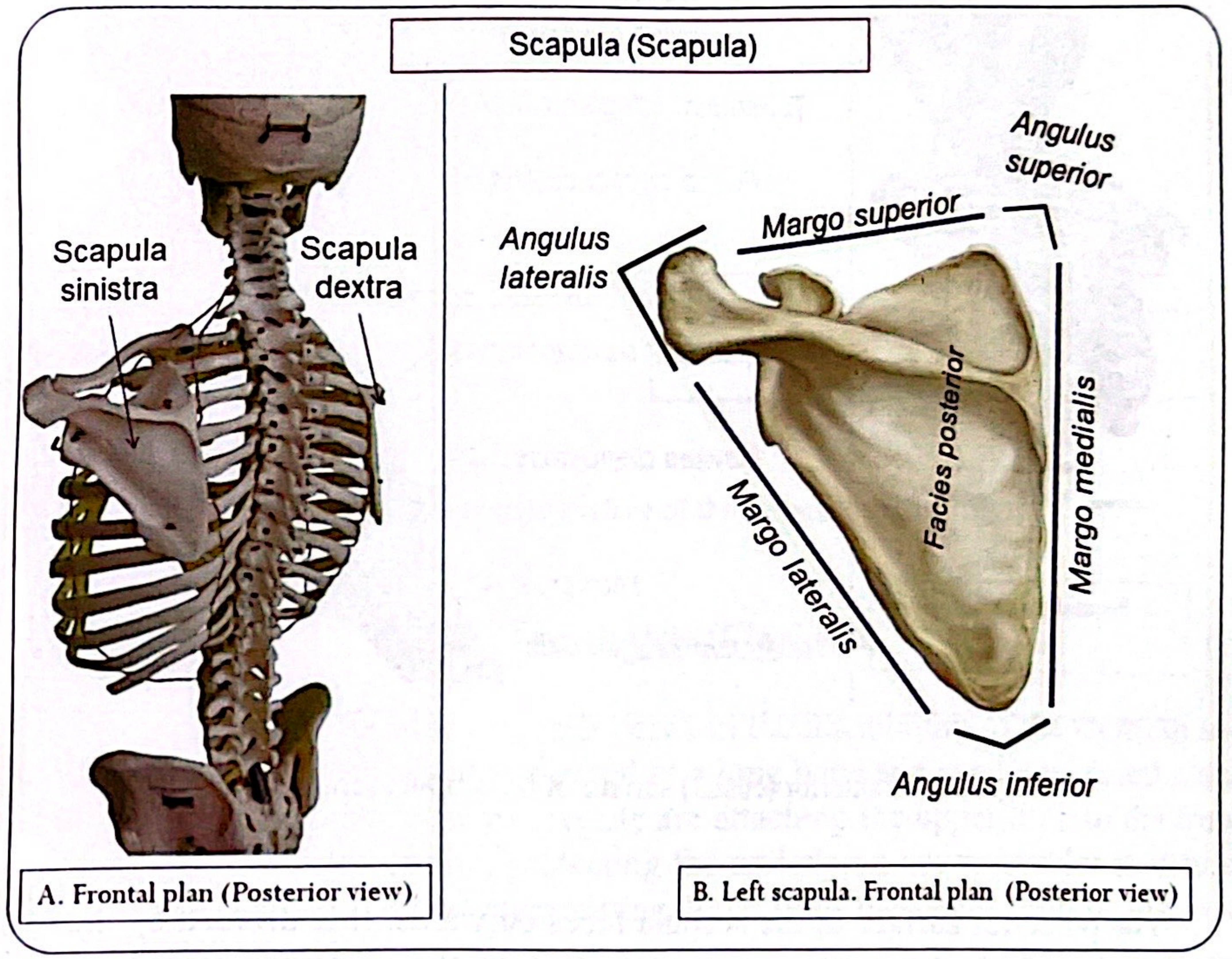


Fig. 22. The scapula (Scapula) (original fig.)

The costal (anterior) surface of the scapula faces the ribcage a large concave depression subscapular fossa (**Fossa subscapularis**) over most of its surface is occupied by subscapular muscles. **Coracoid process (Processus coracoideus)** originate from the superolateral surface of the costal scapula, it is a hook-like projection, which lies just underneath the clavicle.

The lateral surface of the scapula faces the humerus. Glenoid fossa **(Cavitas glenoidalis)** a shallow cavity, is located superiorly on the lateral border and articulates with the head of the humerus to form the glenohumeral (shoulder) joint. Above the superior margin of the glenoid cavity is the supraglenoid tubercle **(Tuberclum supraglenoidale)** and below of it is the infraglenoid tubercle **(Tuberclum infaglenoidale).** There are the places of the origin of muscles of the free upper limb.

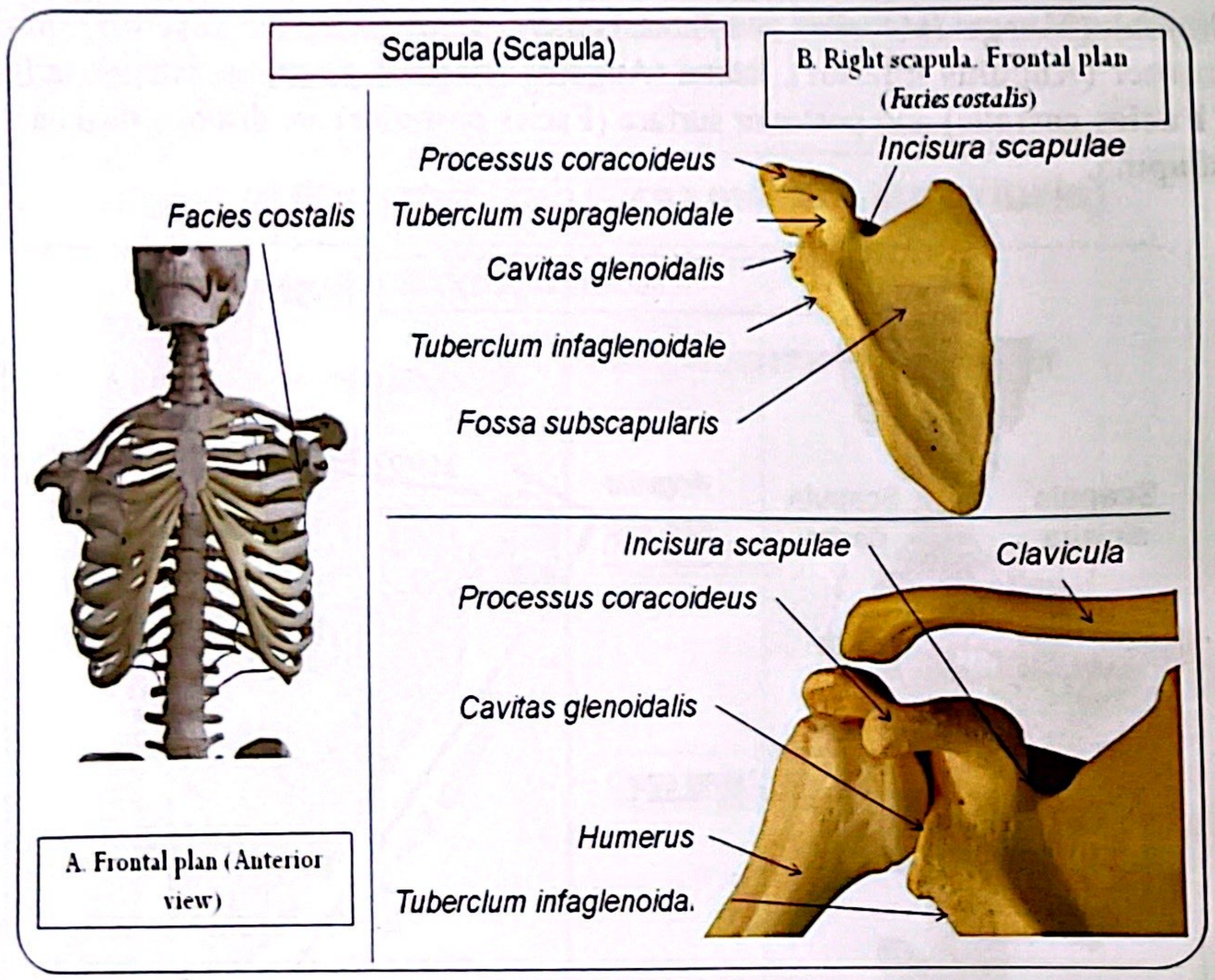


Fig. 23. The anterior (costal) surface of the scapula (original fig.)

The posterior surface of the scapula faces outwards. It is divided by the spine **(Spina scapulae),** the most prominent feature of the posterior scapula. It runs transversely across the scapula, dividing the surface into two: infraspinous fossa **(Fossa infraspinata),** below the spine of the scapula, it displays a convex shape and supraspinous fossa **(Fossa supraspinata)** above the spine of the scapula, it is much smaller than the infraspinous fossa, and is more convex in shape. Scapular notch **(Incisura scapulae)** lays in the medial part of the upper border of supraspinous fossa for the vessels and nerves. The strongly developed lateral part of spine of scapula that arches over the glenohumeral joint and articulates with the clavicle at the acromioclavicular joint is the acromion **(Acromion).**

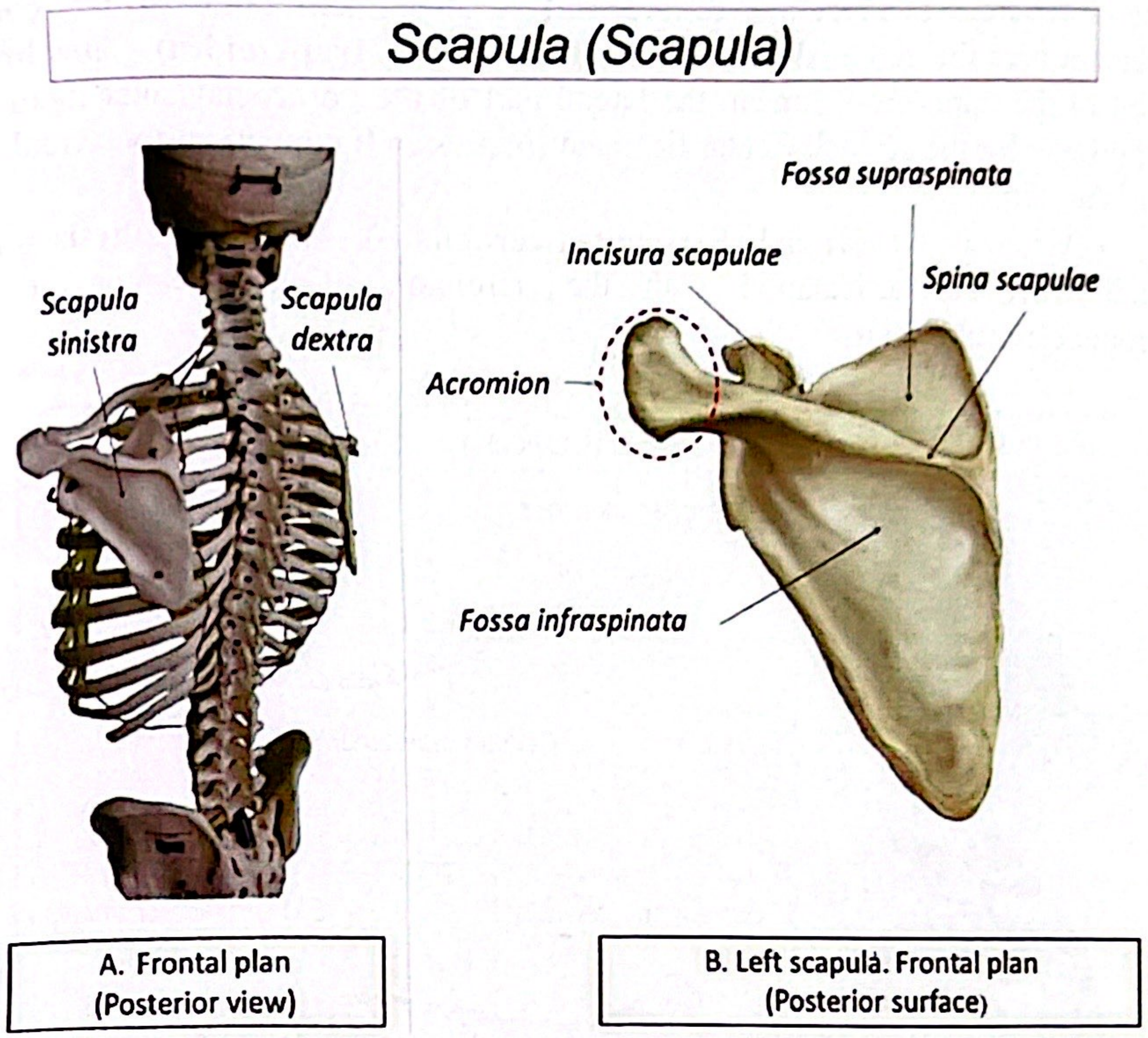


Fig. 24. The posterior surface of the scapula (original fig.)

2.1.2. The clavicle (Clavicula)

The clavicle (collarbone) extends between the manubrium of the sternum and the acromion of the scapula. It is classed as a long bone and can be palpated along its length. The main functions of clavicle are attaching the upper limb to the trunk as part of the 'shoulder girdle', protecting the underlying neurovascular structures supplying the upper limb and transmitting force from the upper limb to the axial skeleton.

The clavicle is small, "S"-shape bone. Facing forward, the medial aspect is convex, and the lateral aspect concave. It can be divided into:

- Sternal **(medial)** end **(Extremitas sternalis)** – proximal epiphysis – contains a large, round shape facet for articulation with the manubrium of the sternum at the sternoclavicular joint.
- Body, shaft **(Corpus clavicularis) – diaphysis** – is long, compress form top to bottom and curved from anterior to posterior side. The superior surface of the body is smooth. The inferior surface has points for attachment with the muscles:

conoid tubercle **(Tuberclum conoideum)** is attachment point of the conoid ligament near the acromial end, trapezoid line **(Linea trapezoidea)** – attachment point of the trapezoid ligament, the lateral part of the coracoclavicular ligament, impression for the costoclavicular ligament (impressio ligamenti costoclavicularis) near the sternal end.

- Acromial (lateral) end **(Extremitas acromialis) – distal epiphysis** – is a small facet for articulation with the acromion of the scapula at the acromioclavicular joint.

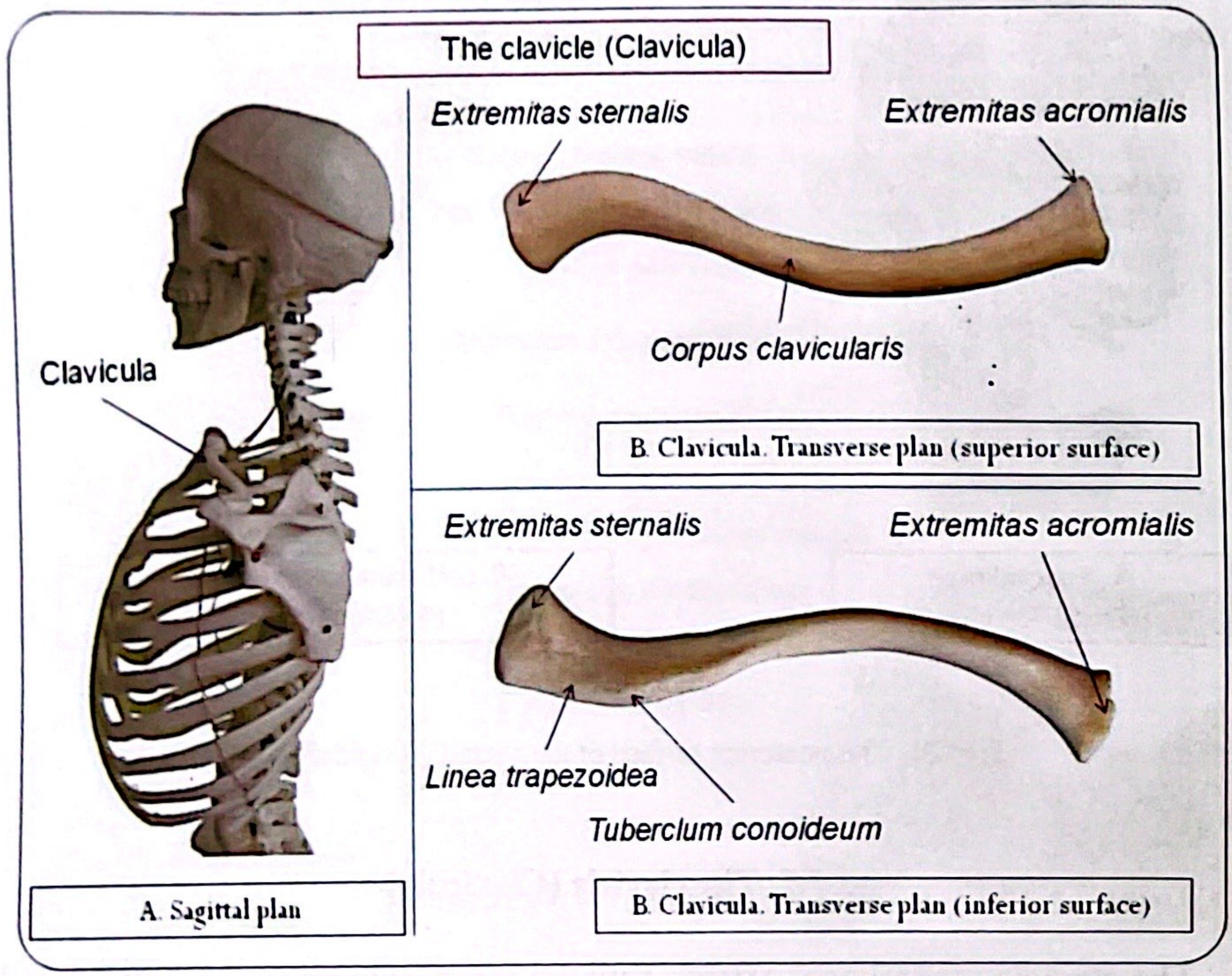


Fig. 25. The clavicle (original fig.)

2.2. Bones of the free upper limb (Pars libera membri superioris)

2.2.1. Bones of the arm

The upper arm bones consist of the humerus.

The **Humerus** is a long bone of the upper limb, which extends from the shoulder to the elbow. The proximal aspect of the humerus articulates with the glenoid fossa of the scapula, forming the glenohumeral joint. Distally, at the elbow joint, the humerus articulates with the **head of the radius** and **trochlear notch of the ulna.**

Since bones of the arm and forearm are a typical long bone, the following parts can be distinguished in it:

- Proximal epiphysis **(Epiphysis proximalis).**
- Proximal metaphysis **(Metaphysis proximalis).**
- **Diaphysis humeri.**
- Distal metaphysis **(Metaphysis distalis).**
- Distal epiphysis **(Epiphysis distalis).**

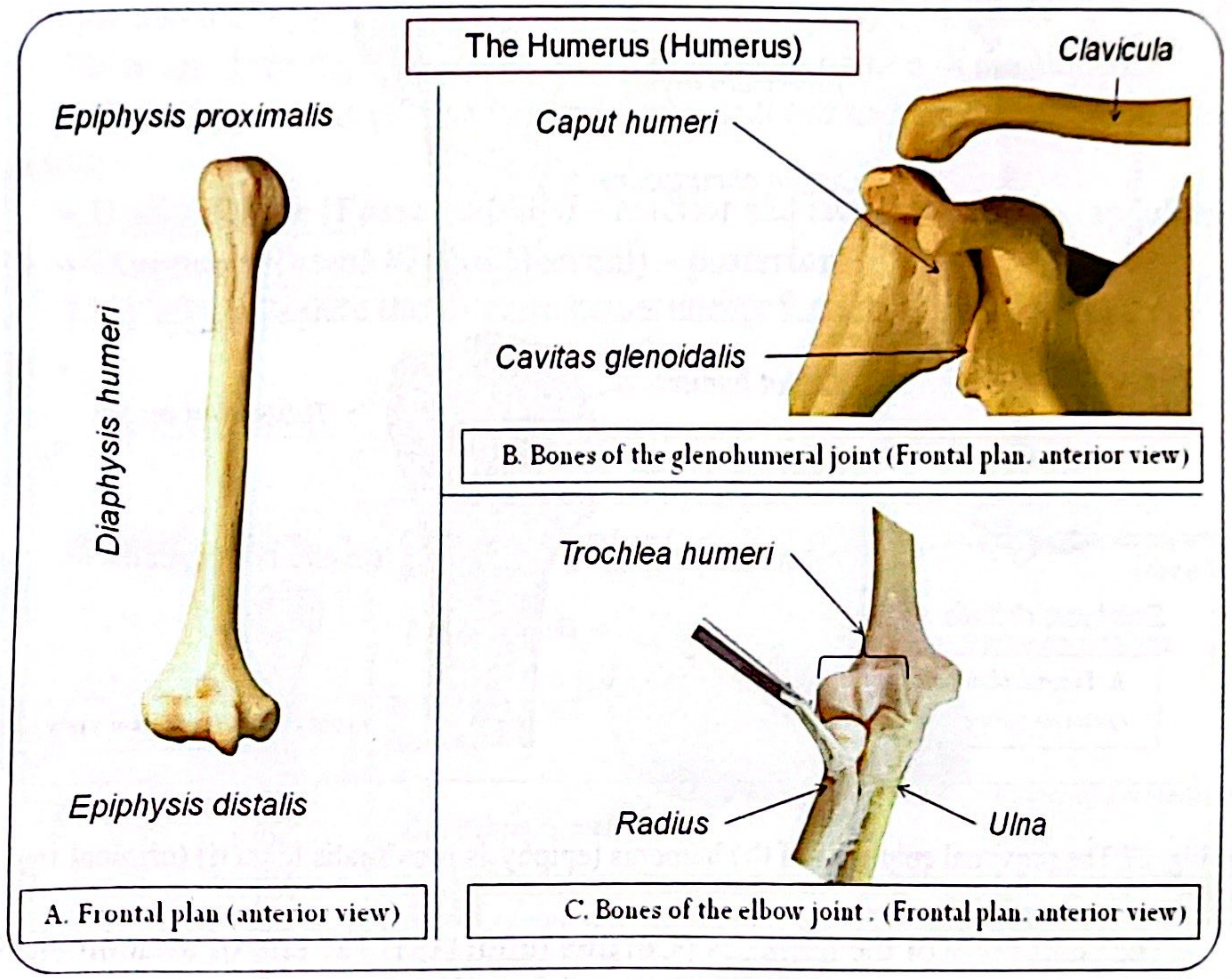

The Humerus (Humerus)
Epiphysis proximalis
Diaphysis humeri
Epiphysis distalis
A. Frontal plan (anterior view)
Clavicula
Caput humeri
Cavitas glenoidalis
B. Bones of the glenohumeral joint (Frontal plan. anterior view)
Trochlea humeri
Radius
Ulna
C. Bones of the elbow joint. (Frontal plan. anterior view)

Fig. 26. The humerus (original fig.)

The **proximal** end of the humerus consists of the **head (Caput humeri)**. This faces (NB! *it help you to understand the right anatomical position of the bone*): Medially! Upwards, Backwards.

The head is separated from the greater and lesser tubercles by **the anatomical neck (Collum anatomicum)**. The **greater tubercle (Tuberclum majus)** is located **laterally** on the humerus. The **lesser tubercle (Tuberclum minus)** is much smaller, and more **medially** located on the bone. Separating the two tubercles is a deep groove, known as the **intertubercular sulcus (Sulcus intertubercularis)**. The tendon of the long head of the biceps brachii **(Tendo capitis longi musculus bicipitis brahii)** emerges from the shoulder joint and runs through this groove.

The **surgical neck (Collum chirurgicum)** runs from just distal to the tubercles to the shaft of the humerus and corresponding to the zone of the epiphyseal cartilage.

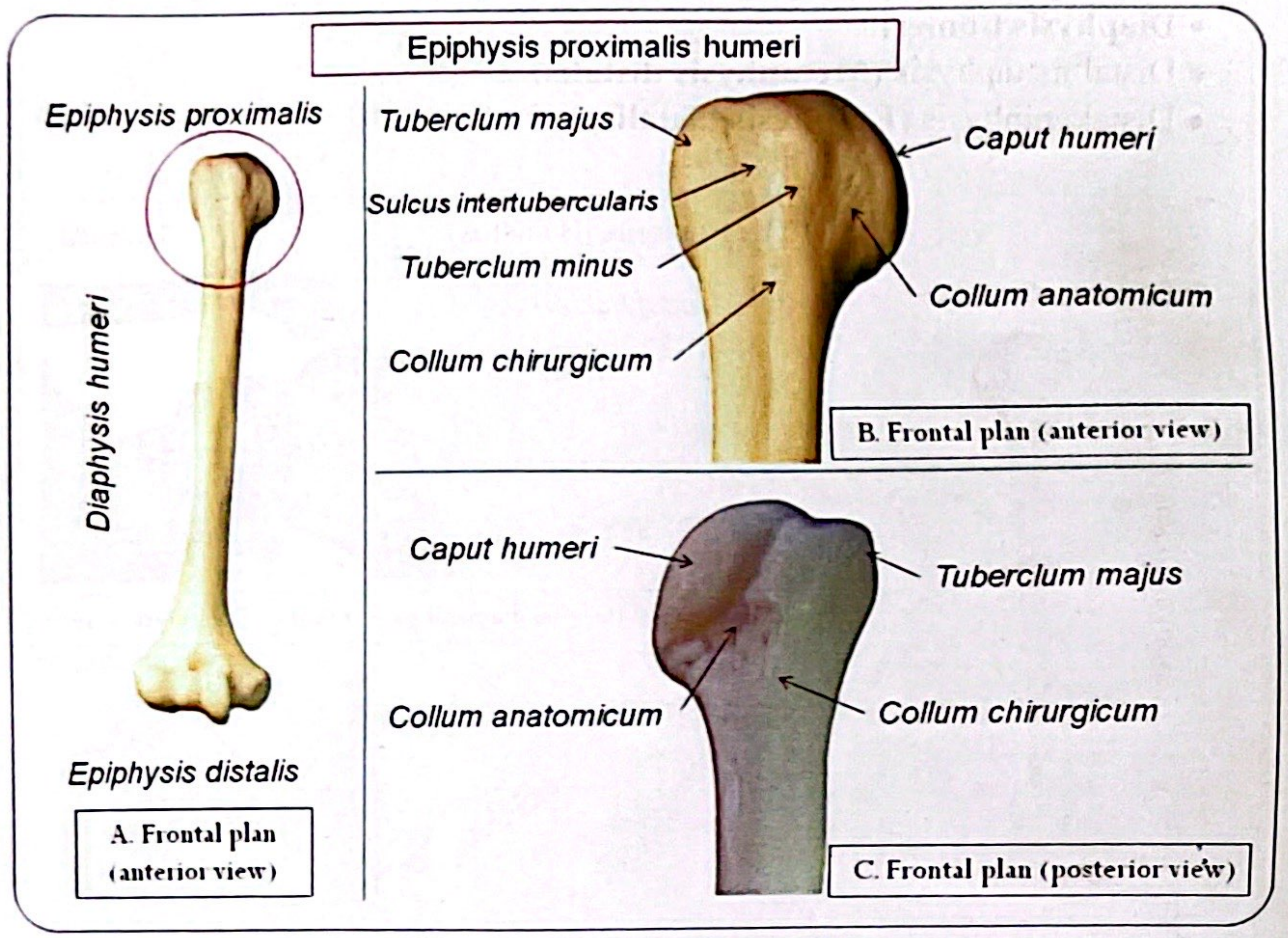


Fig. 27 The proximal epiphysis of the humerus (epiphysis proximalis humeri) (original fig.)

The shaft/body of the humerus **(Corpus humeri)** is the site of attachment for various muscles. Cross section views reveal it to be circular proximally (round) and flattened distally (trihedral) and posterior, anterolateral and anteromedial surfaces are distinguished in the lower part of the body. Deltoid tuberosity **(Tuberositas deltoidea)** is on the anterolateral surface where the deltoid muscle attaches to the humeral shaft. The **radial (or spiral) groove (Sulcus radialis/spiralis)** is a shallow depression that runs diagonally down the posterior surface of the humerus, parallel to the deltoid tuberosity. The radial nerve and deep brachial vessels lie in this groove.

The lateral and medial borders of the distal epiphysis form medial and lateral **supraepicondylar ridges (Cristae supraepicondylaris lateralis et medialis)**. The lateral supraepicondylar ridge is more roughened, providing the site of common origin of the forearm extensor muscles. The **lateral** and **medial epicondyles (Epicondylus lateralis et medialis)** are extracapsular projections of bone immediately distal to the supraepicondylar ridges. Both can be palpated at the elbow. The medial is the larger of the two and extends more distally. The **ulnar nerve** passes in a groove **(Sulcus nervi ulnaris)** on the posterior aspect of the medial epicondyle where it is palpable.

Distally the distal epiphysis carries the condyle **(Condylus humeri)** which is subdivided into two parts (*NB! it help you to understand the right anatomical position of the bone*):

- The trochlea **(Trochlea humeri)** is located **medially**, and extends onto the posterior aspect of the bone which articulates with the ulna.
- The capitulum **(Capitulum humeri)** is **laterally**, which articulates with the trochlear notch of radius.

There are three depressions located on the distal portion of the humerus:

- **Coronoid fossae (Fossa coronoidea)** – anterior and medial (above the trochlea).
- **Radial fossae (Fossa radialis)** – anterior and lateral (above the capitulum)
- **Olecranon fossae (Fossa olecrani) – posterior.**

They accommodate the forearm bones during flexion or extension at the elbow.

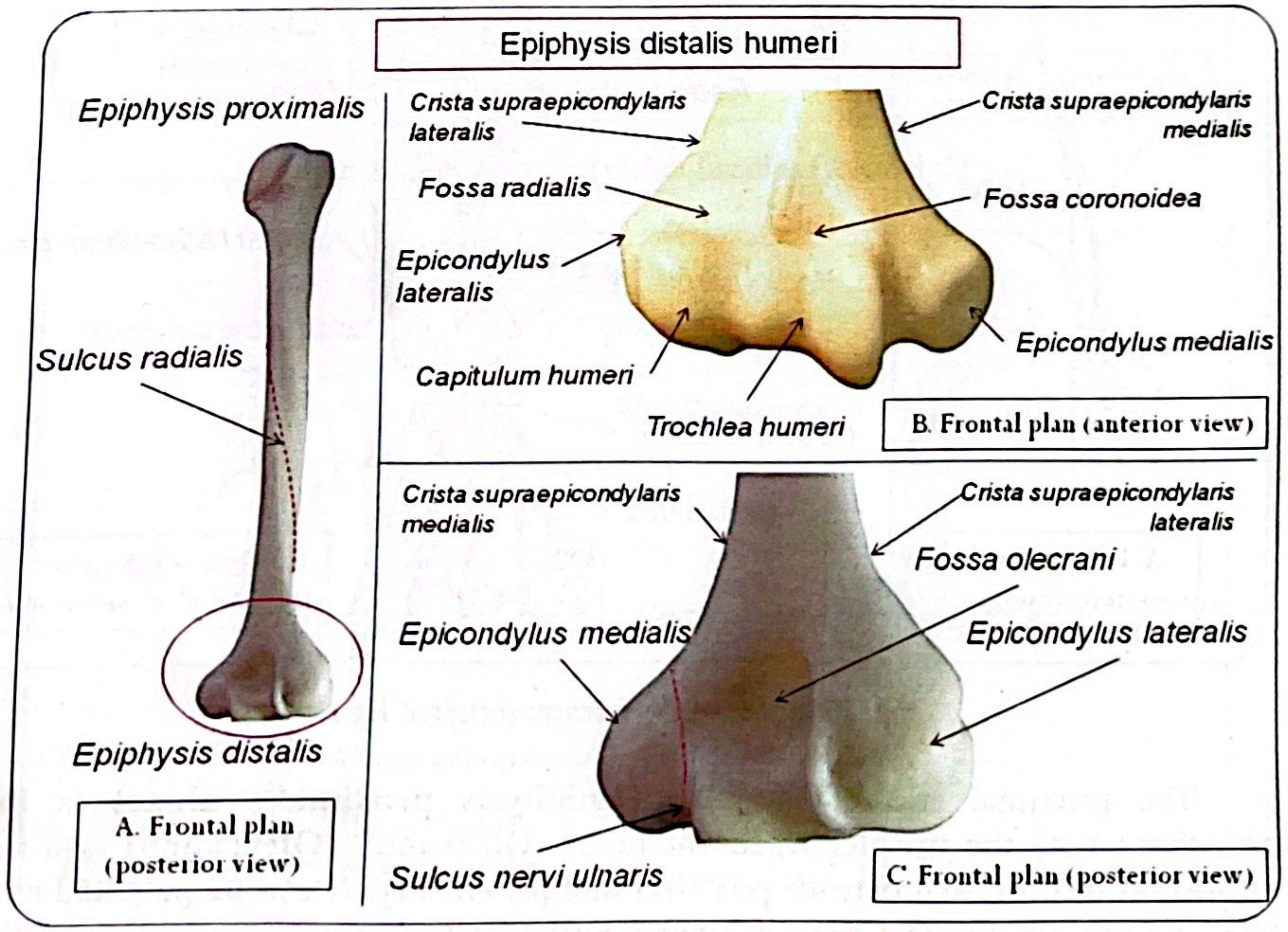

Epiphysis distalis humeri
Epiphysis proximalis
Sulcus radialis
Epiphysis distalis
A. Frontal plan (posterior view)
Crista supraepicondylaris lateralis
Crista supraepicondylaris medialis
Fossa radialis
Fossa coronoidea
Epicondylus lateralis
Epicondylus medialis
Capitulum humeri
Trochlea humeri
B. Frontal plan (anterior view)
Crista supraepicondylaris medialis
Crista supraepicondylaris lateralis
Fossa olecrani
Epicondylus medialis
Epicondylus lateralis
Sulcus nervi ulnaris
C. Frontal plan (posterior view)

Fig. 28. The distal epiphysis of the humerus (epiphysis distalis humeri) (original fig.)

2.2.2. Bones of the forearm

The bones of the forearm are **ulna** (medially) and **radius** (laterally).

2.2.2.1. The ulna (Ulna)

The **ulna** is a long bone in the forearm. Proximally, the ulna articulates with the **humerus** at the elbow joint. Distally, the ulna articulates with the **radius**, forming the distal radio-ulnar joint.

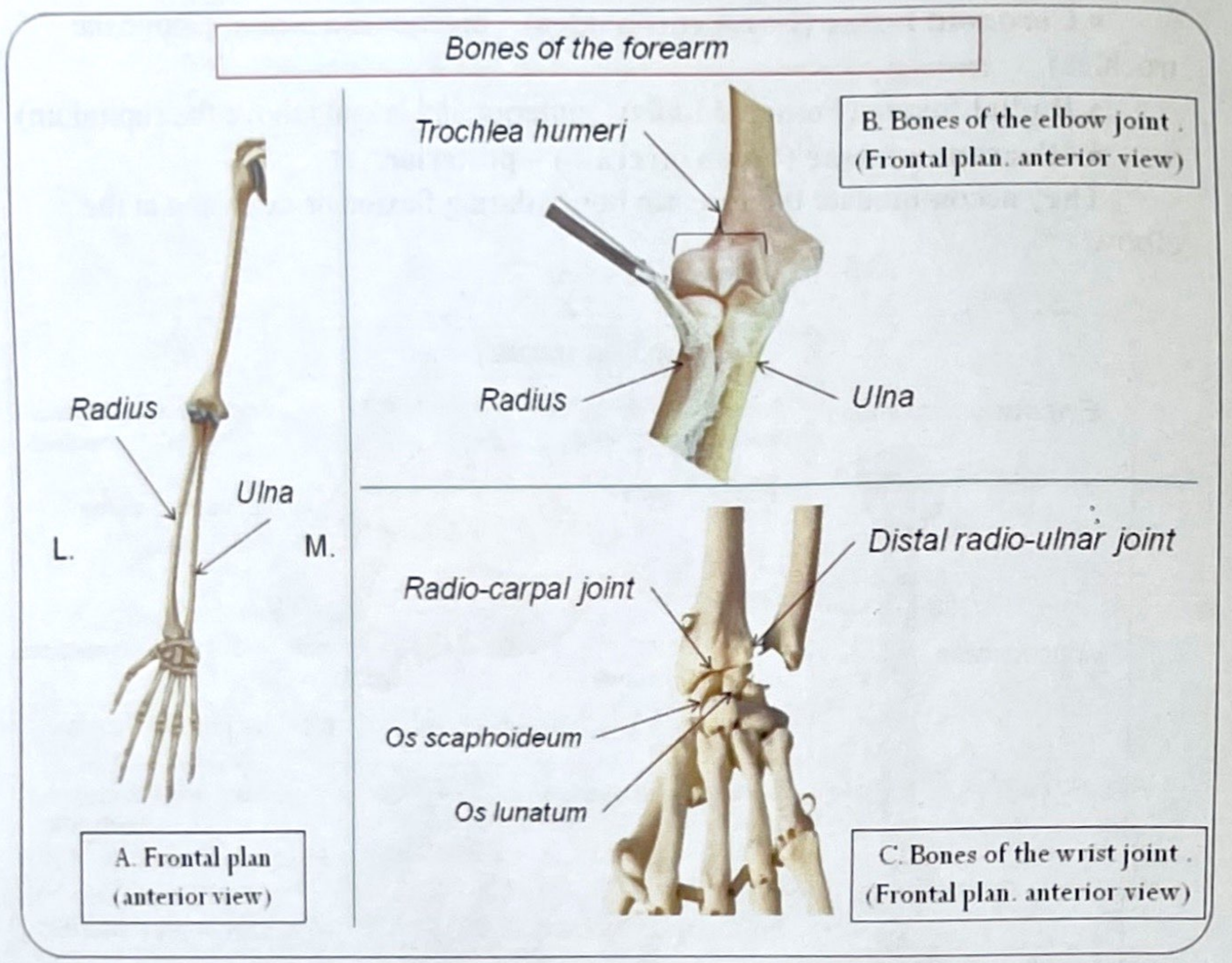

Bones of the forearm
Trochlea humeri
B. Bones of the elbow joint (Frontal plan. anterior view)
Radius
Ulna
L.
M.
Radius
Ulna
Distal radio-ulnar joint
Radio-carpal joint
Os scaphoideum
Os lunatum
A. Frontal plan (anterior view)
C. Bones of the wrist joint (Frontal plan. anterior view)

Fig. 29. Bones of the forearm (original fig.)

The proximal end of the ulna **(Epiphysis proximalis ulnae)** is thick articulates with the trochlea of the humerus. **Olecranon (Olecranon)** is a large projection of bone that extends posterior and proximally. It can be palpated as the "tip" of the elbow. The triceps brachii muscle attaches to its superior surface. **Coronoid process (Process coronoideus)** is this ridge of bone projects anteriorly and distally. **Trochlear notch (Incisura trochlearis)** is formed by the olecranon and coronoid process. It is "C"-shaped, and articulates with the trochlea of the humerus. The lateral surface of the coronoid process carries the radial notch **(Incisura radialis)**, this area articulates with the head of the radius.

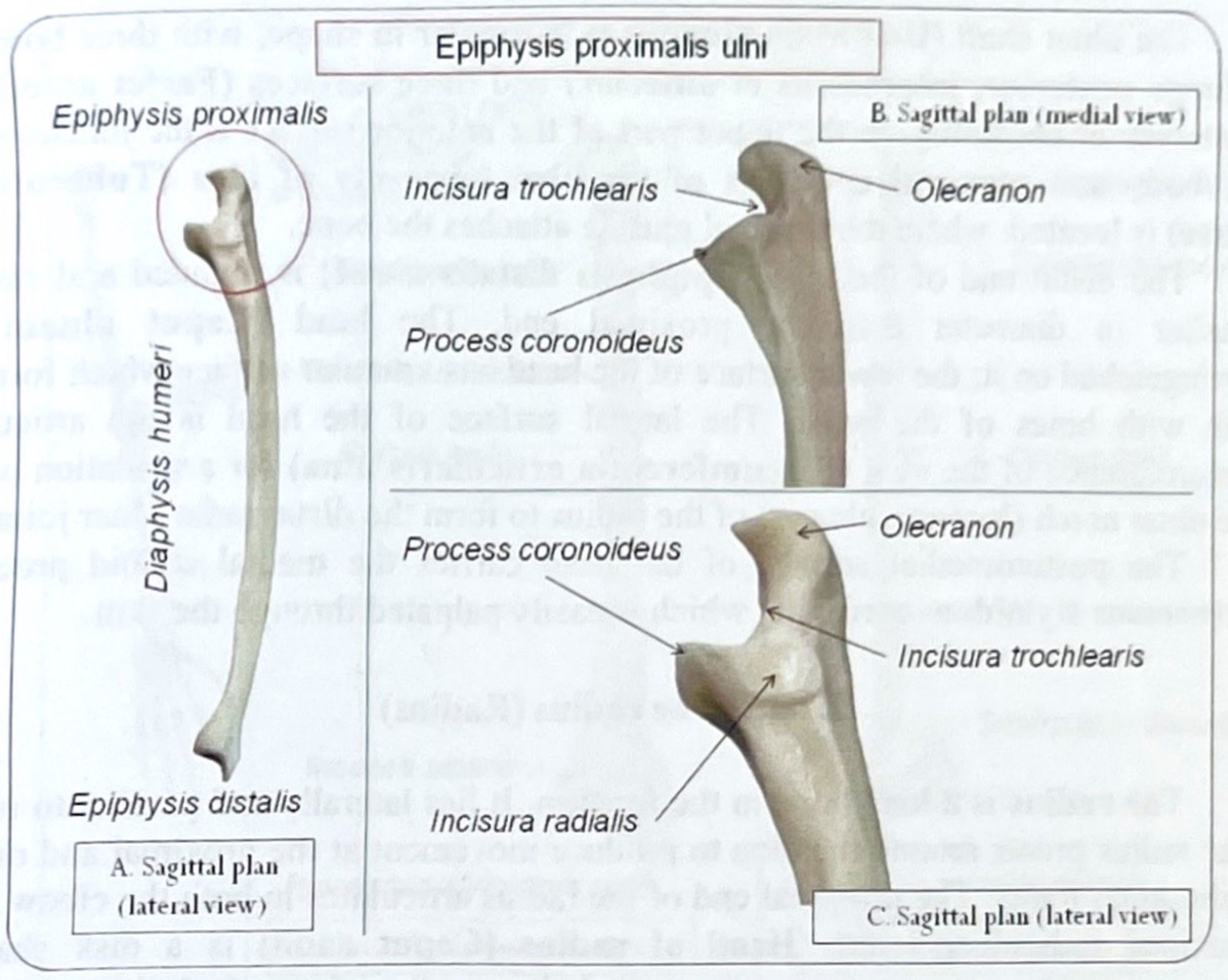


Fig. 30. The proximal end of the ulna (original fig.)

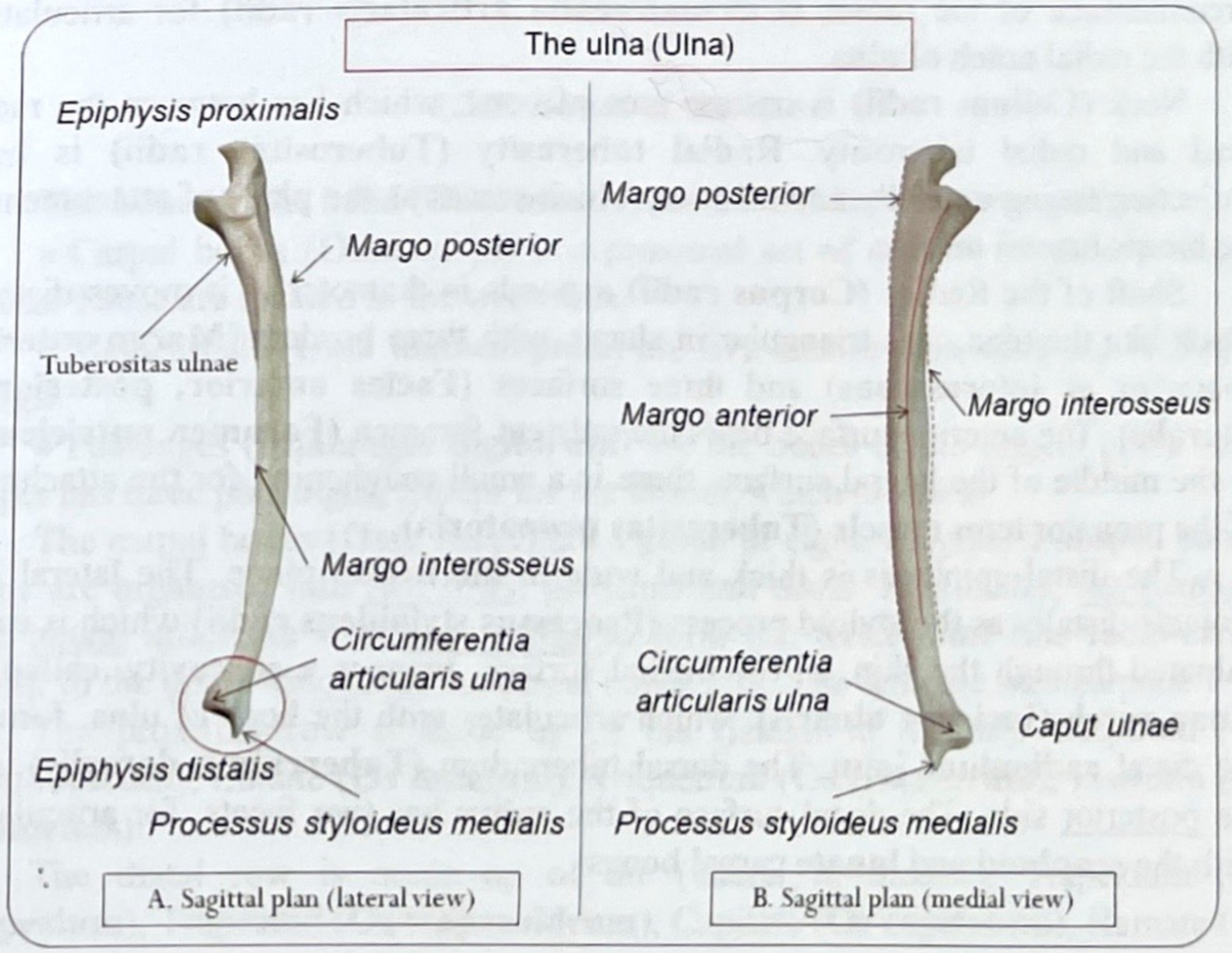

The ulna (Ulna)
Epiphysis proximalis
Margo posterior
Margo posterior
Tuberositas ulnae
Margo anterior
Margo interosseus
Margo interosseus
Circumferentia articularis ulna
Circumferentia articularis ulna
Caput ulnae
Epiphysis distalis
Processus styloideus medialis
Processus styloideus medialis
A. Sagittal plan (lateral view)
B. Sagittal plan (medial view)

Fig. 31. The diaphysis and distal end of the ulna (original fig.)

The ulnar shaft (**Diaphysis ulnaris**) is triangular in shape, with three borders (**Margo posterior, interosseus et anterior**) and three surfaces (**Facies anterior, posterior et medialis**). In the upper part of the anterior surface o the junction of the body and proximal epiphysis of the ulna tuberosity of ulna (**Tuberositas ulnae**) is located, where the brachial muscle attaches the bone.

The distal end of the ulna (**Epiphysis distalis ulnae**) is rounded and much smaller in diameter than the proximal end. The head (**Caput ulnae**) is distinguished on it; the lower surface of the head has articular surface which form a join with bines of the wrist. The lateral surface of the head is the articular circumference of the ulna (**Circumferentia articularis ulna**) for articulation with the ulnar notch (Incisura ulnaris) of the radius to form the distal radio-ulnar joint.

The posteromedial surface of the head carries the medial styloid process (**Processus styloideus medialis**) which is easily palpated through the skin.

2.2.2.2. The radius (Radius)

The **radius** is a long bone in the forearm. It lies laterally and parallel to ulna. The radius pivots around the ulna to produce movement at the proximal and distal radio-ulnar joints. The proximal end of the radius articulates in both the elbow and proximal radioulnar joints. **Head of radius (Caput radii)** is a disk shaped structure, with a concave superior articulating surface for articulation with the capitulum humeri. The lateral surface of the head carries the articular circumference of the radius (**Circumferentia articularis radii**) for articulation with the radial notch of ulna.

Neck (**Collum radii**) is narrow area of bone, which lies between the radial head and radial tuberosity. **Radial tuberosity (Tuberositas radii)** is bony projection facing medially and anterior, which serves as the place of attachment of the biceps brachii muscle.

Shaft of the Radius (**Corpus radii**) expands in diameter as it moves distally. Much like the ulna, it is triangular in shape, with three borders (**Margo anterior, posterior et interosseous**) and three surfaces (**Facies anterior, posterior et lateralis**). The anterior surface bears the nutrient foramen (**Foramen nutricicum**). In the middle of the lateral surface, there is a small roughening for the attachment of the pronator teres muscle (**Tuberositas pronatoria**).

The distal epiphysis is thick and wide in the frontal plane. The lateral side projects distally as the styloid process (**Processus styloideus radii**) which is easily palpated through the skin. In the medial surface, there is a concavity, called the **ulnar notch (Incisura ulnaris)**, which articulates with the head of ulna, forming the distal **radioulnar joint**. The dorsal tuberculum (**Tuberculum dorsalis**) is on the posterior side. The distal surface of the radius has two facets, for articulation with the **scaphoid** and **lunate** carpal bones.

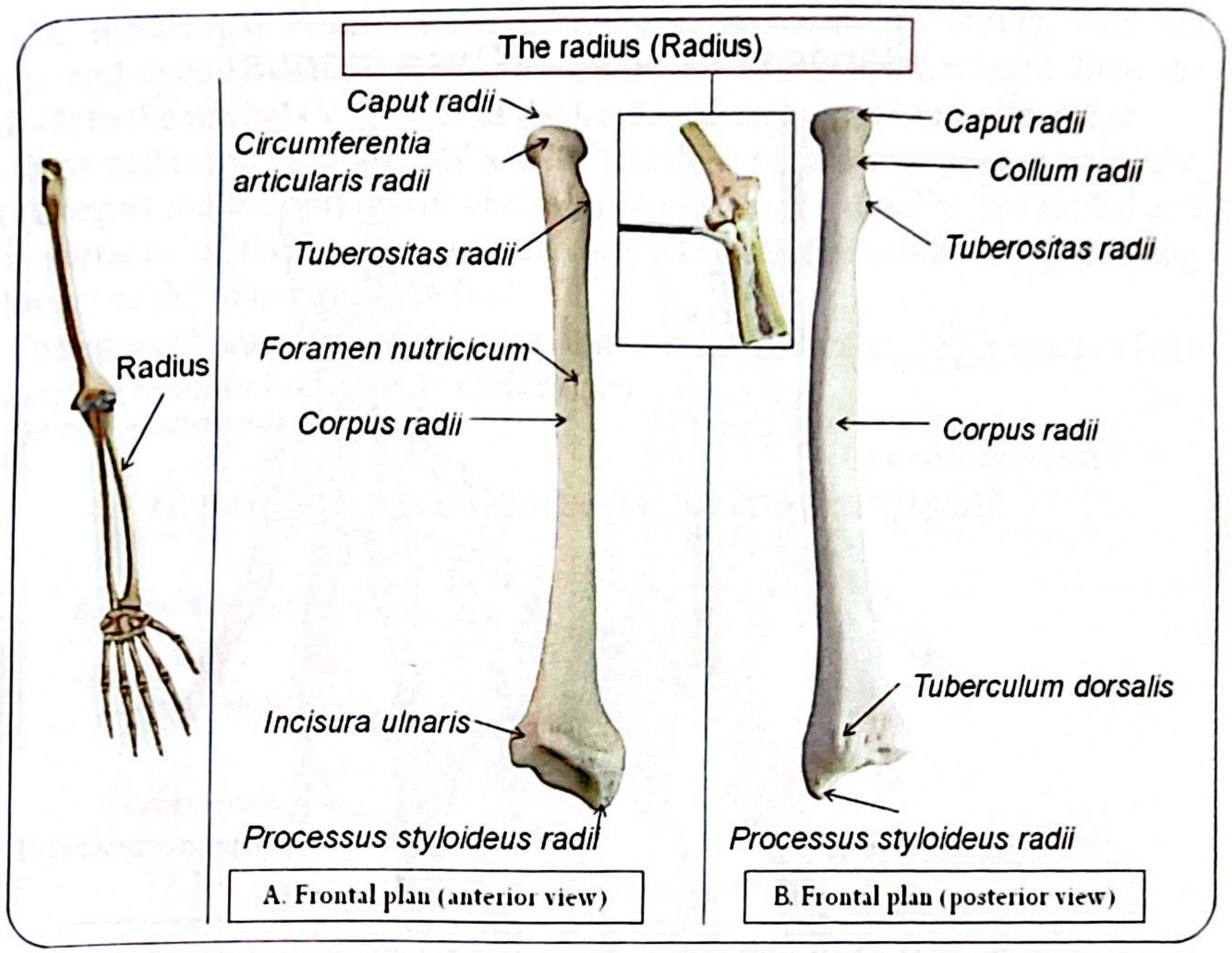


Fig. 32. The proximal end and body of the radius (original fig.)

2.2.3. Bones of the hand

The bones of the hand (**Ossa manus**) can be divided into three groups:

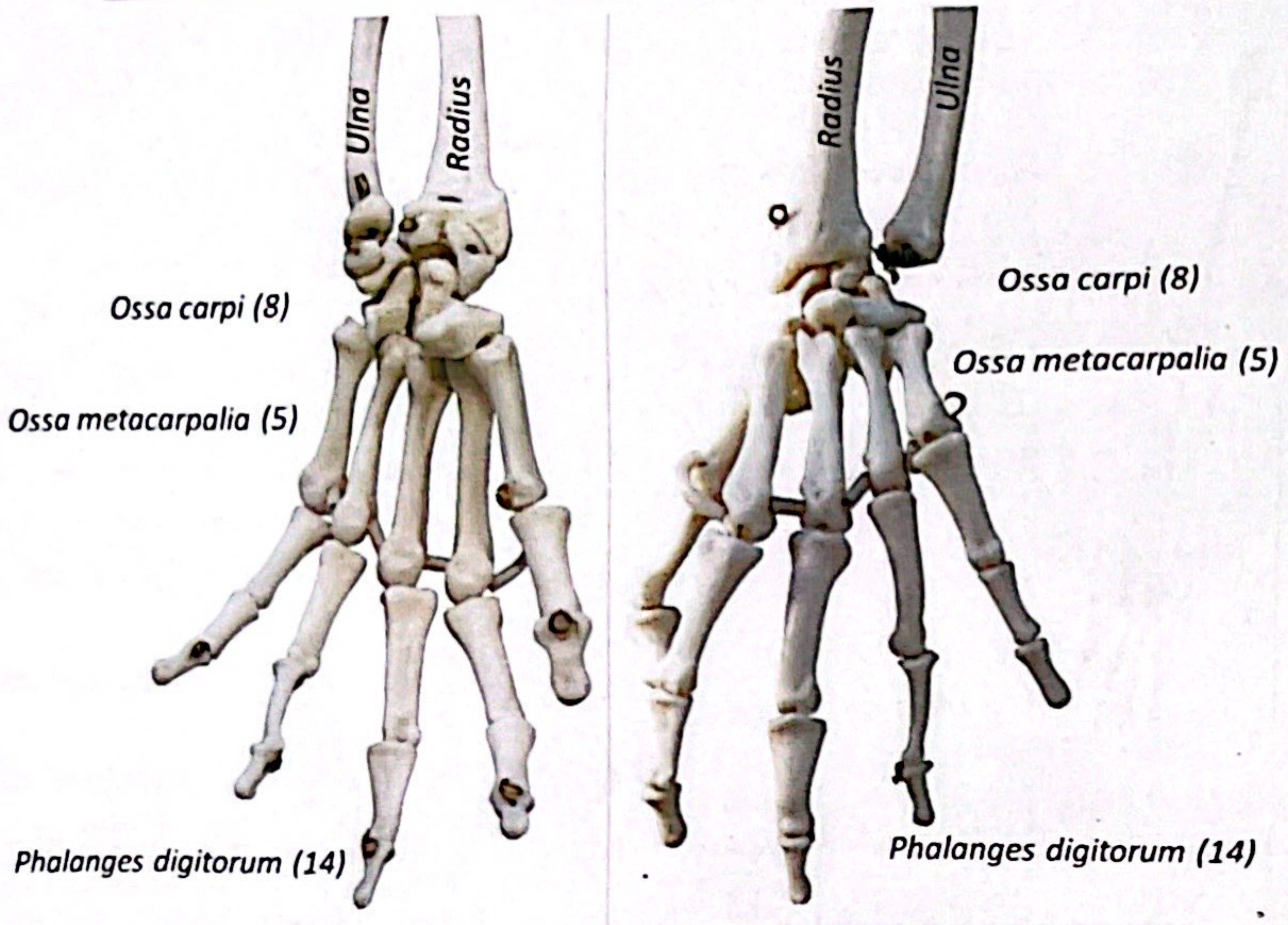
- Carpal bones (**Ossa carpi**) is a proximal set of eight 8 irregularly shaped bones. These are located in the wrist area.
- Metacarpals (**Ossa metacarpalia**) are five metacarpals, each one related to a digit.
- Phalanges (**Phalanges digitorum**) are the bones of the fingers (14!). Each finger has three phalanges, except for the thumb, which has two.

The carpal bones (**Ossa carpi**) are a group of eight, irregularly shaped bones. They are organised into two rows: proximal and distal. Proximally, the scaphoid and lunate articulate with **the radius** to form the **wrist joint** (the radio-carpal joint). In the distal row, all of the carpal bones articulate with the metacarpals.

The proximal row is made up of the (lateral to medial): Scaphoid (**Os scaphoideum**), Lunate (**Os lunatum**), Triquetrum (**Os triquetrum**), Pisiform (**Os pisiformis**).

The distal row is made up of the (lateral to medial): Trapezium (**Os trapezium**), Trapezoid (**Os trapezoideum**), Capitate (**Os capitatum**), Hamate (**Os hamatum**).

Bones of the hand (Ossa manus)

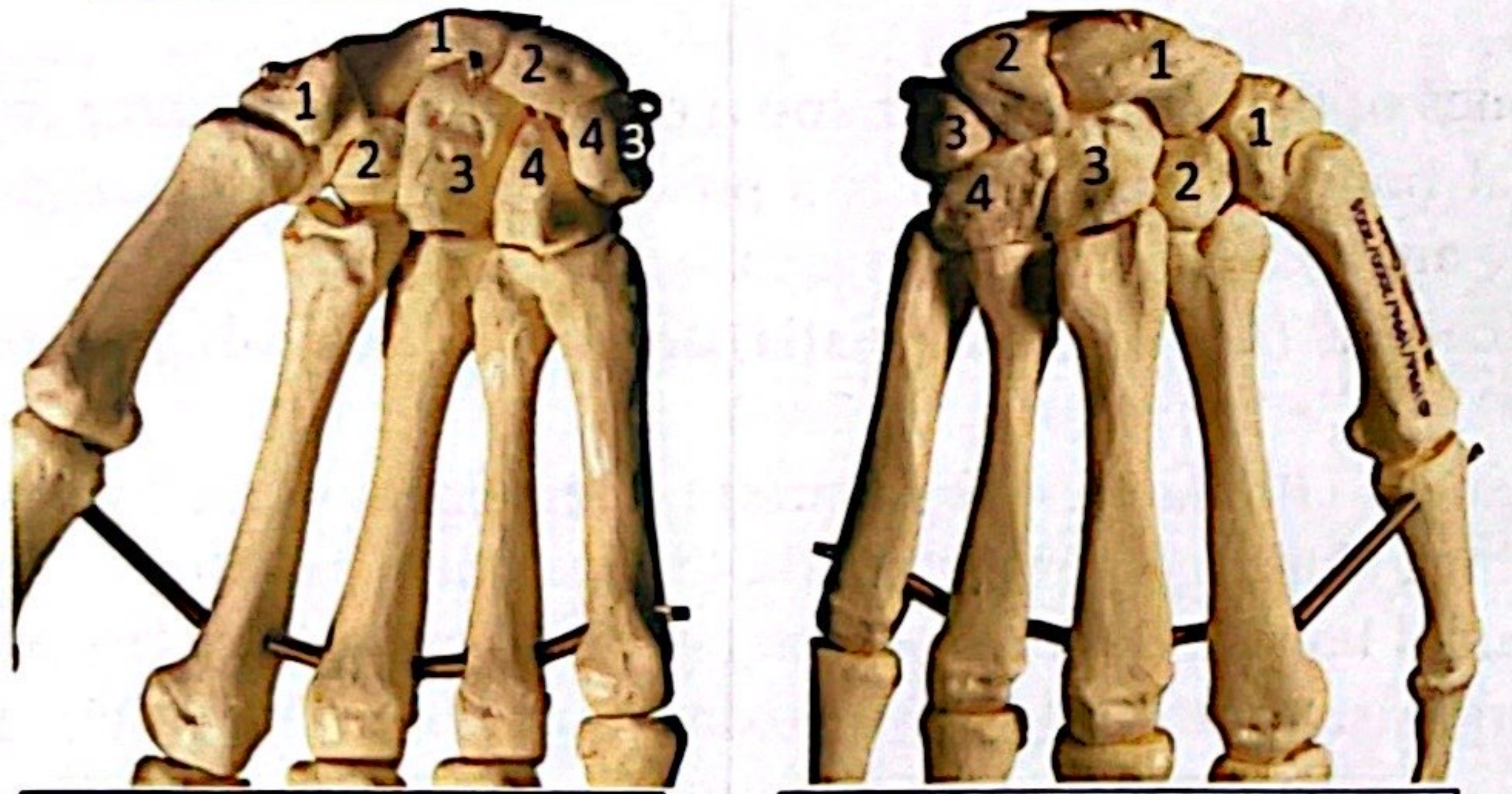


A. Frontal plan (palmar view)

B. Frontal plan (dorsal view)

Fig. 33. The bones of the hand (ossa manus) (original fig.)

The carpal bones (Ossa carpi)



A. Frontal plan (palmar view)

B. Frontal plan (dorsal view)

Proximal Row (*lateral to medial*)	Distal Row (lateral to medial)
1. Scaphoid (Os scaphoideum) 2. Lunate (Os lunatum) 3. Triquetrum (Os triquetrum) 4. Pisiform (Os pisiforme) *(*a sesamoid bone, formed within the tendon of the flexor carpi ulnaris)	1. Trapezium (Os trapezium) 2. Trapezoid (Os trapezoideum) 3. Capitate (Os capitatum) 4. Hamate (Os hamatum) (*has a projection on its palmar surface, known as the 'hook of hamate')*

Fig. 34. The carpal bones (original fig.)

The metacarpal bones (**Ossa metacarpi**) articulate proximally with the carpals, and distally with the proximal phalanges. They are numbered from the lateral (I) to the medial (V) border of the hand, and each associated with a digit.

Each metacarpal consists of a base **(Basis ossis metacarpi)** – proximally, shaft **(Corpus metacarpi)** and head **(Caput metacarpi)** – distally. The medial and lateral surfaces of the metacarpals are concave form the palmar side, **allowing** attachment of the interossea muscles.

The spaces between the metacarpal banes are called interosseous spaces of the metacarpus (**Spatiae interosseae metacarpi**)

The metacarpal bones (Ossa metacarpalia)

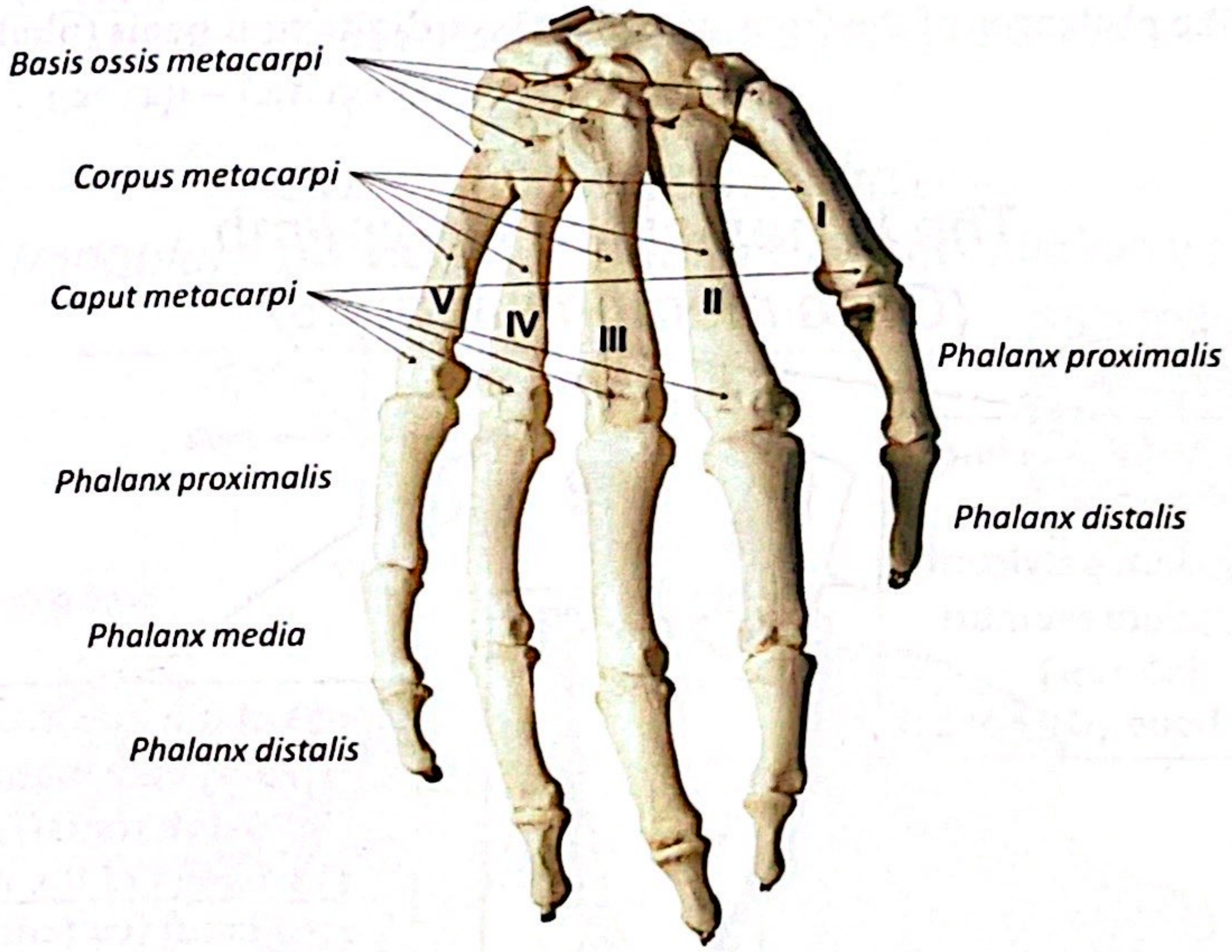


Fig. 35. The metacarpal bones. The phalanges (Dorsal view) (original fig.)

The phalanges (**Phalanges digitorum**) are the small and tubular bones of the fingers. The thumb has a proximal (phalanx proximalis) and distal phalanx (phalanx distalis), while the rest of the digits have proximal, middle (phalanx media) and distal phalanges.

The body (**Corpus phalanges**), the base (**Basis phalangis**) – proximally and head (**Caput phalangis**) – distally are distinguished in each phalanx.

Sesamoid bones are also found occasionally in the muscle tendons of the palmar surface at the metacarpophalangeal joints of the thumb, index and little fingers.

Chapter III. Bones of the appendicular skeleton.
Anatomy of the bones of the lower limb

The lower limb (extremity) has some special functions: 1. Locomotion, 2. Bearing the weight and 3. Maintaining the equilibrium. The bones of the lower limb **(Ossa membri inferioris)** can be divided into two functional groups: the pelvic girdle **(Cingulum pelvicum/Cingulum membri inferior)** including the hip (innominate) bones **(Ossa coxae)**, which connects the lower limb to the axial skeleton, and the bones of the free lower limb **(Pars libera membri inferioris)**, which include the femur in the thigh, tibia and fibula in the leg, patella, and the bones of the feet: tarsal bones **(Ossa tarsi)** – bones of the posterior and middle part of the foot, metatarsal bones **(Ossa metatarsi)** – bones of the anterior part of the foot, and the phalanges of the digits of foots **(Ossa digitorum pedis (phalanges))**.

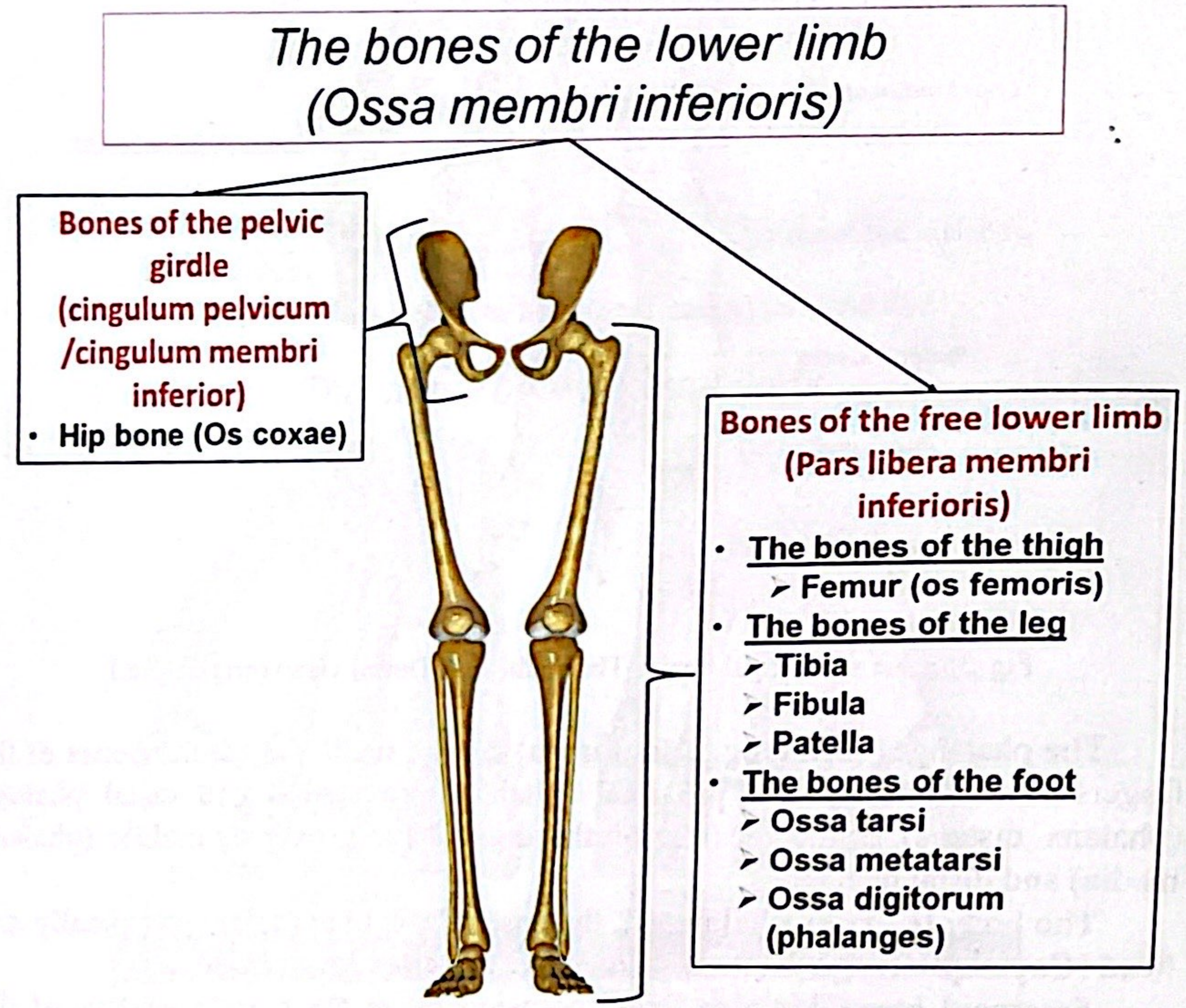


Fig. 36. The bones of the lower limb (Ossa membri inferioris) (original fig.)

3.1. Bones of the pelvic girdle (Cingulum pelvicum/Cingulum membri inferior)

The hip bones are joined anteriorly by means of a fibrous cartilage – the pubic symphysis and posteriorly with the sacrum; together they form a ring termed the bony pelvis.

The hip bone is the large, irregularly shaped bone which is firmed by **an ilium (Os ilium)** forms the superior portion, **an ischium (Os ischium)** forms the *lower posterior* portion, and **an pubis (Os pubis)** the lower anterior portion. At birth, these three components are separated by hyaline cartilage. By the age 15–17 years three bones will have fused together, and at 23–25 they will have ossified (indistinguishably join). They join each other in a "Y"-shaped portion of cartilage in the acetabulum – a cup-shaped socket on the lateral external aspect of the hip bane for articulation with the head of the femur (*its resemblance to a shallow Roman vinegar cup – Lat. acetabulum*)

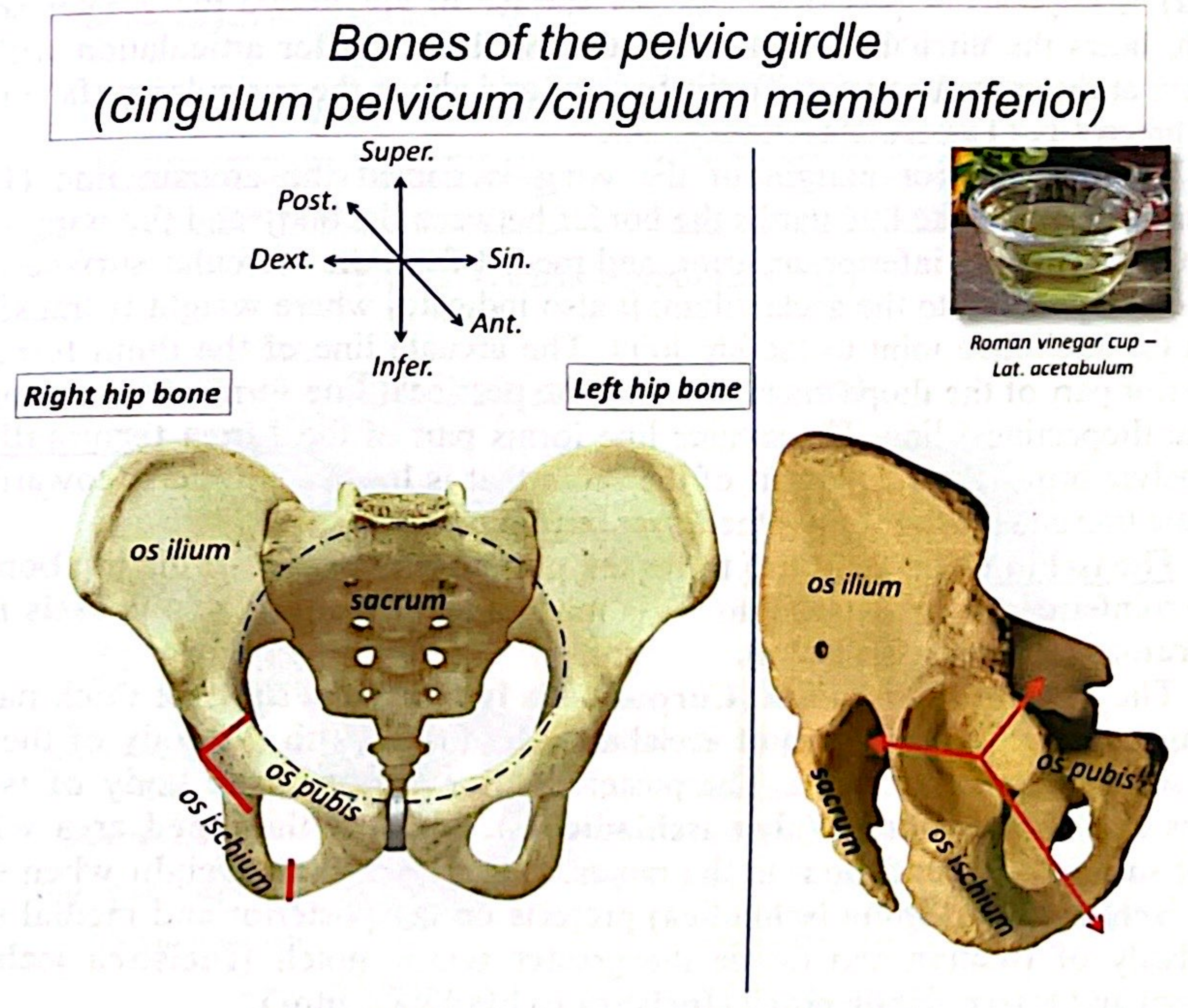


Fig. 37. The hip (Os coxae) (original fig.)

The ilium makes up the upper region of the hip bone and can be subdivided into two parts: 1. the body **(Corpus ossis ilii)** – an inferior region, which form the upper port of the acetabulum and 2. the wing **(Ala ossis ilii)** – a superior, fanned out portion.

The thickened superior margin of the wing is named the **iliac crest (Crista iliaca)** and carries three lines (lips) for attachment to muscles (labium externum, labium internum, linea intermedia). The iliac crest ends anteriorly in **anterior superior iliac spine (Spina iliaca anterior superior)** (it may be easily palpated and visible), and posteriorly in **the posterior superior iliac spine (Spina iliaca posterior superior)** (a middle of a sacroiliac joints).

Below the anterior superior iliac spine the anterior end of the ala has a lunate notch which is limited below by the anterior inferior iliac spine **(Spina iliaca anterior inferior)** below of which the ala continuous to the body of ilium and pubis. Below the posterior superior iliac spine the posterior end of the ala has the posterior inferior iliac spine **(Spina iliaca posterior inferior)** below of which the ala continuous to the greater sciatic notch **(Incisura ischiadica major)** – the larger U-shaped indentation at the posterior margin of the lower ilium and upper ischium.

The ala of the ilium has two surfaces: 1. Lateral (external) or **Gluteal surface (Facies glutea),** which bears marks of the origin of the gluteus muscles (posterior, anterior and inferior gluteal lines) 2. Medial (internal) surface is concave anteriorly and forms the lower part of the abdominal wall and is called the iliac fossa **(Fossa iliaca)**. The posterior part of the medial surface of ala, above the greater sciatic notch, bears the **auricular surface (Facies auricularis)** for articulation with the sacrum at the sacroiliac joint. To the back of and above the auricular surface is the iliac tuberosity **(Tuberositas iliaca).**

The thin inferior margin of the wing is named the arcuate line **(Linea arcuata)**. The arcuate line marks the border between the body and the wing of the ilium, and, running inferior, anterior, and medial from the auricular surface to the area corresponding to the acetabulum; it also indicates where weight is transferred from the sacroiliac joint to the hip joint. The arcuate line of the ilium forms the posterior part of the iliopectineal line and the pectineal line forms the anterior part of the iliopectineal line. The arcuate line forms part of the **Linea terminalis** and the pelvic brim. The pelvic part of the ilium that is located inferiorly towards the arcuate line adds to the wall of the lesser or true pelvis.

The ischium (Os ischium) forms the posteroinferior part of the hip bone and posteroinferior part of acetabulum. It is made up of a **body (Corpus ossis ischii)** and **ramus (Ramus ossis ischii).**

The body of the ischium (Corpus ossis ischii) is the superior thick part and forms the posteroinferior part of acetabulum by fusing with the body of the ilium and superior ramus of pubis. The posteroinferior aspect of the body of ischium forms **the ischial tuber (Tuber ischiadicum),** which is thickened area with the blunt surface and continuous to the ramus. It bears our body weight when sitting. **The ischial spine (Spina ischiadica)** projects on the posterior and medial side of the body of ischium and divide the greater sciatic notch **(Incisura ischiadica major)** and **lesser sciatic notch (Incisura ischiadica minor).**

The **sacrospinous ligament** attached to the ischial spine and forms a boundary of the greater (inferior border) and lesser sciatic foramen (superior border). The **sacrotuberous ligament** convert the lesser sciatic foramen (inferior border). These foramens provide a passageway for structures to pass from the pelvis into the gluteal region, lower limb and perineum.

The ischial ramus combines with the inferior pubic ramus forming **the ischiopubic ramus (Ramus ischiopubicus),** which encloses part of the obturator foramen.

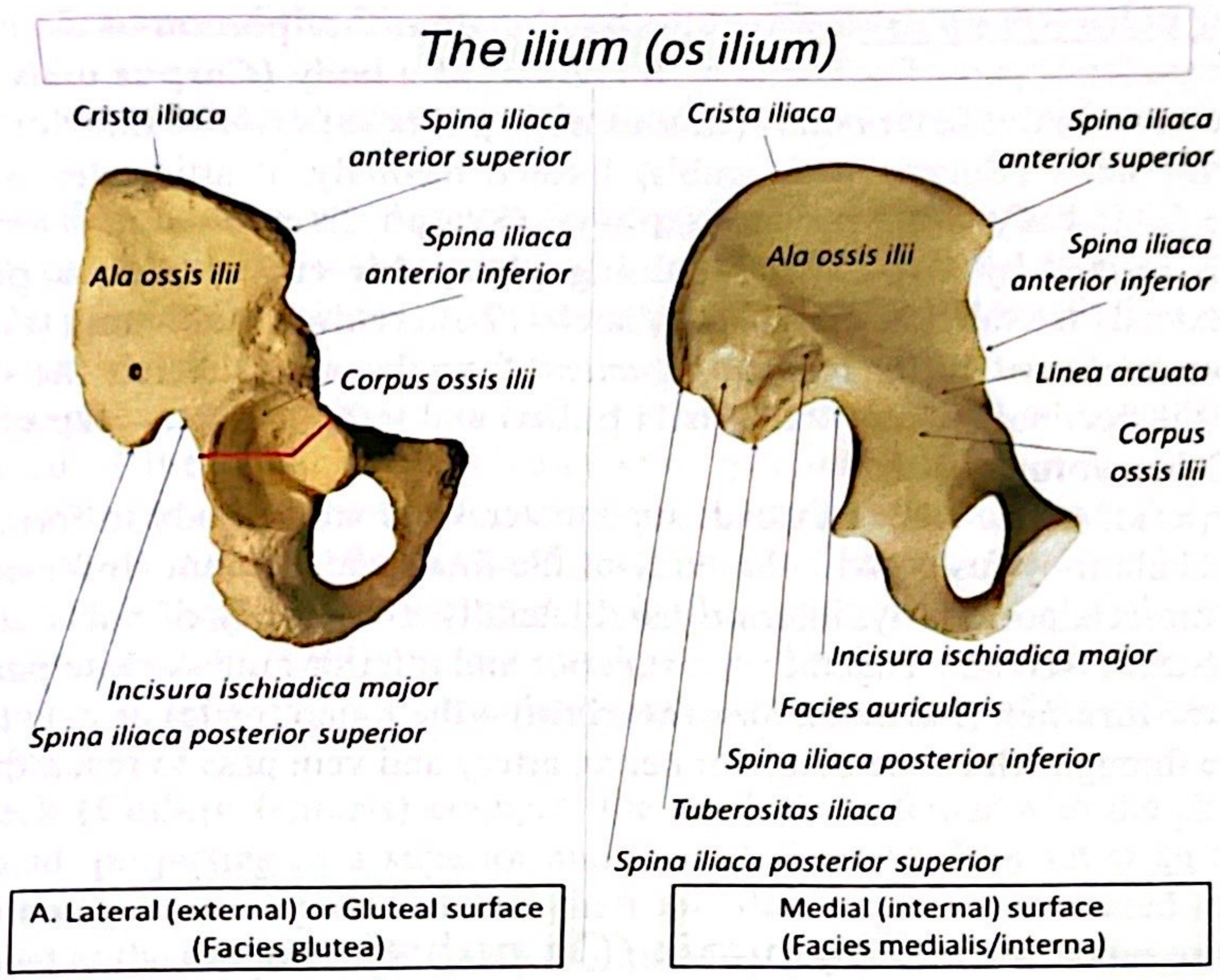

The ilium (os ilium)
Crista iliaca
Spina iliaca anterior superior
Spina iliaca anterior inferior
Ala ossis ilii
Corpus ossis ilii
Incisura ischiadica major
Spina iliaca posterior superior
Crista iliaca
Spina iliaca anterior superior
Ala ossis ilii
Spina iliaca anterior inferior
Linea arcuata
Corpus ossis ilii
Incisura ischiadica major
Facies auricularis
Spina iliaca posterior inferior
Tuberositas iliaca
Spina iliaca posterior superior
A. Lateral (external) or Gluteal surface (Facies glutea)
Medial (internal) surface (Facies medialis/interna)

Fig. 38. The iliac bone (original fig.)

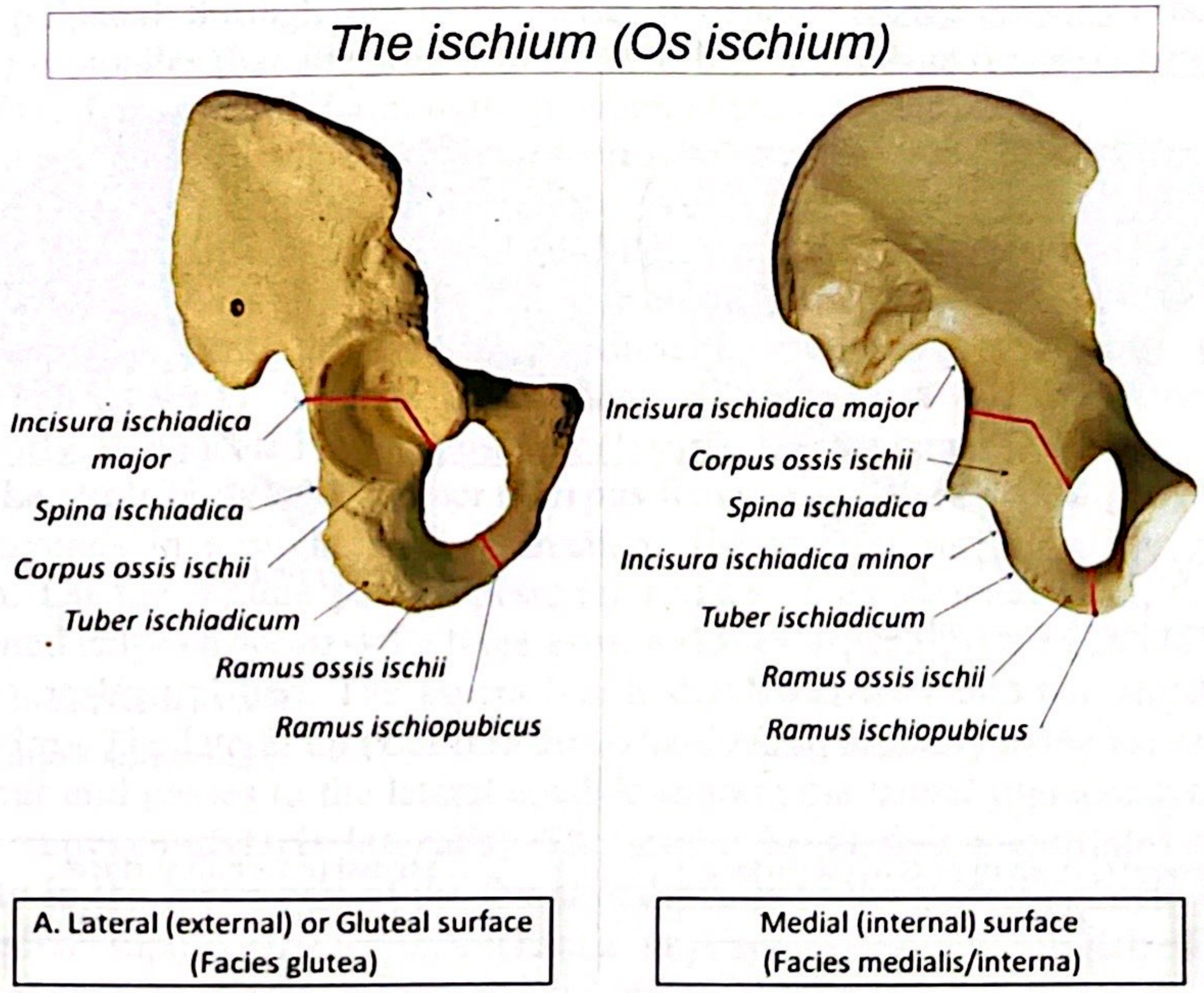
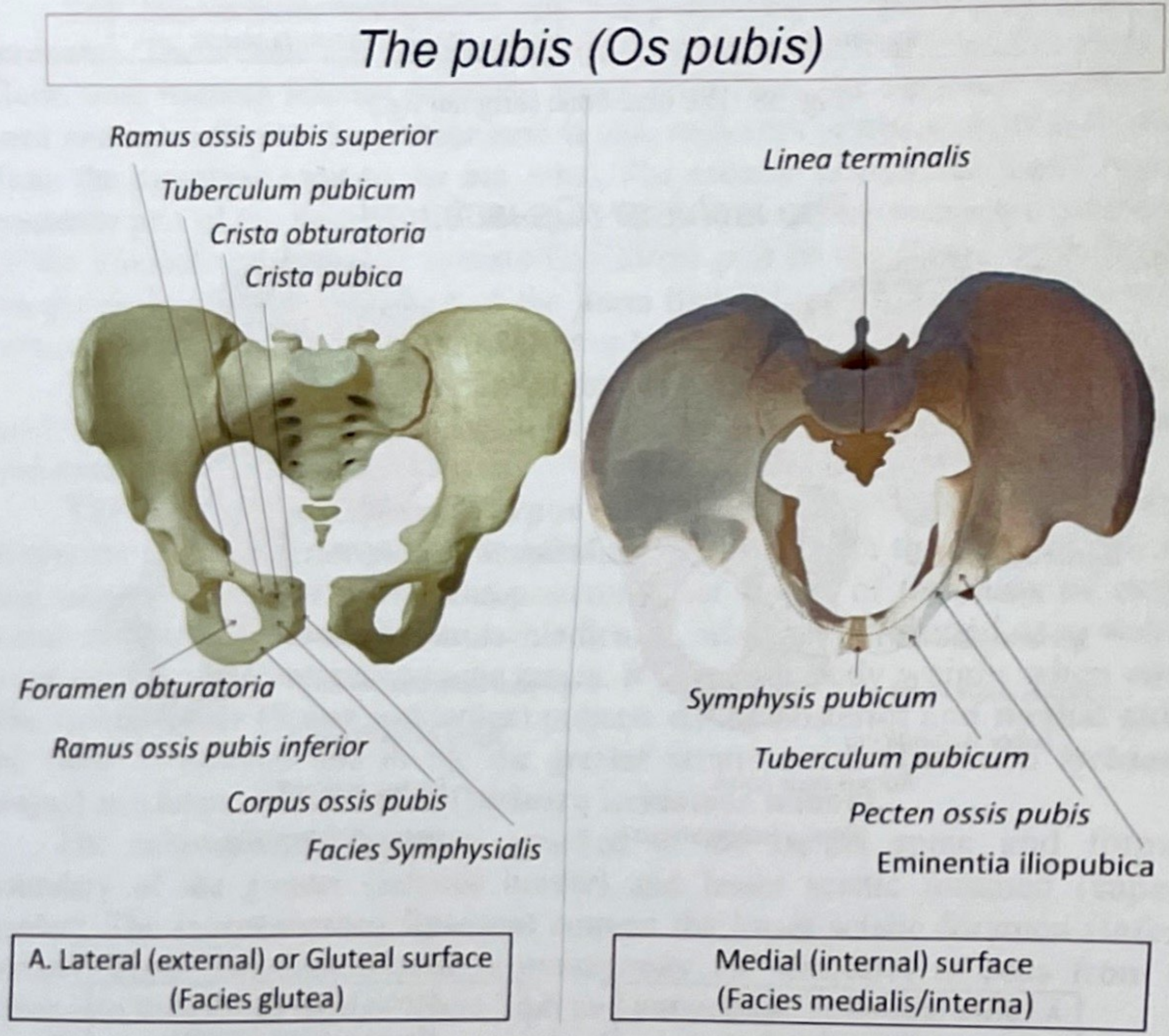


Fig. 39. The ischiatic bone external and internal surfaces (original fig.)

The pubis (Os pubis) is anterior, medial and inferior portion of the hip bone and anteroinferior part of acetabulum. It consists of a body **(Corpus ossis pubis)**, superior ramus and inferior ramus **(Ramus ossis pubis superior et inferior)**.

Pubic body (Corpus ossis pubis) located medially, it articulates with the opposite pubic body at the **pubic symphysis (Symphysis pubicum)**. Its superior aspect is marked by a rounded thickening (**the pubic crest – Crista pubica**), which extends laterally as the pubic tubercle (**Tuberculum pubicum**) (*the main point for attachment for the inguinal ligament*) from the pubic tubercle the superior ridge – the pectineal line (**Pecten ossis pubis**) and inferior ridge – the obturator crest (**Crista obturatoria**).

Superior pubic ramus extends superolaterally from the body to form part of the acetabulum by fusing with the body of the ilium and ischium. **Inferior pubic ramus** projects posteriorly, inferiorly and laterally to the body of pubis and joins with ramus of ischium. Together, the superior and inferior rami enclose part of the **obturator foramen (Foramen obturatorium)** – the round (male) or oval (female) aperture through which the obturator nerve, artery and vein pass to reach the lower limb.



A. Lateral (external) or Gluteal surface (Facies glutea)

Medial (internal) surface (Facies medialis/interna)

Fig. 40. The pubic bone (original fig.)

3.2. Bones of the free lower limb (Pars libera membri inferioris)

3.2.1. The bones of the thigh. Femur (Os femoris)

The femur is the only bone in the thigh and the longest, strongest bone in the body. It can be divided into proximal and distal epiphyses and diaphysis.

The proximal epiphysis of the femur articulates with the acetabulum of the pelvis to form the hip joint.

The proximal epiphysis consists of the head, neck and two trochanters.

Head of the femur **(Caput femoris)** is spherical and has a smooth surface, covered with articular cartilage, except for a small depression which is slightly posterior to its center – the fovea (**Fovea capitis femoris**) – where ligamentum teres attached. The head is directed medially, superiorly and slightly anteriorly (NB! *Do remember it! It help you to understand the right anatomical position and is this bone left or right*) and articulates with the acetabulum of the pelvis to form the hip joint.

Neck **(Collum femoris)** connects the head of the femur with the shaft. It is cylindrical, projecting in a superior and medial direction. It is set at an angle of approximately 125 degrees to the shaft (it allows for an increased range of movement at the hip joint). The neck is limited by the greater and lesser trochanter.

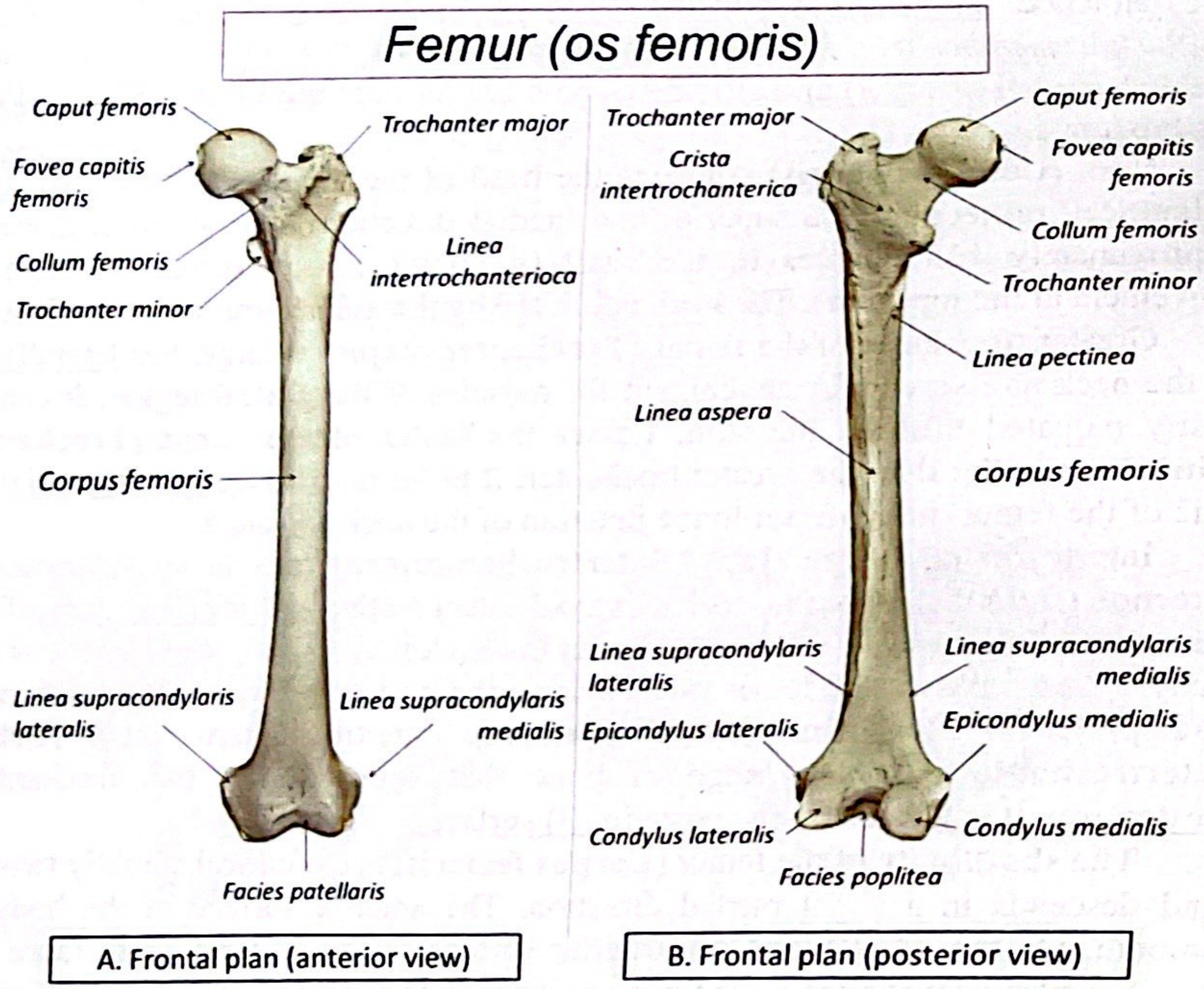
Greater trochanter of the femur **(Trochanter major)** is large, lies laterally (!) to the neck and serves for attachment for muscles of the gluteal region. It can be easily palpated through the skin. Lesser trochanter of the femur **(Trochanter minor)** is smaller than the greater trochanter. It projects from the posteromedial (!) side of the femur, just inferior to the junction of the neck and shaft.

Intertrochanteric line **(Linea intertrochanterioca)** runs in an inferomedial direction (from the greater to the lesser trochanter) on the anterior (!) surface of the femur and separates the anterior surface of the neck from the anterior surface of the body. After it passes the lesser trochanter on the posterior surface, it is known as **the pectineal/spiral line (Linea pectinea).** Intertrochanteric crest **(Crista intertrochanterica)** is a ridge of bone that connects the two trochanters posteriorly. It is located on the posterior (!) surface of the femur.

The shaft/body of the femur (**Corpus femoris**) is cylindrical, slightly twisted and descends in a slight medial direction. The anterior surface of the body is smooth. On the middle part of posterior surface of the femoral shaft, there are roughened ridges of bone – the **linea aspera (Linea aspera),** is the continuation of the pectineal/spiral line. The aspera line is divided distally into two (medial and lateral) lips. The lateral lip (**Labium laterale**) deviates laterally in the lower part of the femur and passes to the lateral condyle to form the lateral supracondylar lines **(Linea supracondylaris lateralis)**. The medial lip (**Labium mediale**) deviates medially in the lower part of the femur and passes to the medial condyle to form the medial supracondylar lines **(Linea supracondylaris medialis).** The flat **popliteal surface (Facies poplitea)** lies between them.

The distal end of the femur (epiphysis distalis femoris) is thick, wide and characterized by the presence of the medial and lateral condyles, which articulate with the tibia and patella to form the knee joint. **Medial and lateral condyles (Condylus medialis et lateralis)** are rounded areas which separates by the deep U-shaped intercondylar notch **(Fossa intercondylaris)**. The posterior and inferior surfaces articulate with the tibia and menisci of the knee, while the anterior surface carry the patellar surface **(Facies patellaris)** where it articulates with the patella.

Superior to each condyle is a prominent epicondyle to which tibial and fibular collateral ligaments are attached. **Medial and lateral epicondyles (Epicondylus medialis et lateralis)** – bony elevations on the non-articular areas of the condyles. The medial epicondyle is the larger.



A. Frontal plan (anterior view)

B. Frontal plan (posterior view)

Fig. 41. Femur (Os femoris) (original fig.)

3.2.2. The patella knee cap (Patella)

The patella knee cap is the sesamoid bone, which is located in the tendon of the quadriceps femoris muscle. The upper border is rounded – patellar base **(Basis patellae)**, the lower border – apex of the patella **(Apex patellae)**, the anterior surface is rough, the posterior – articular surface is divided by a vertical ridge.

3.2.3. The bones of the leg (Ossa cruris)

The leg is the inferior part of the lower limb between the knee and ankle joints. The tibia (*located medially*) and fibula (*located laterally*) are the bones of the leg.

3.2.3.1. The tibia (Tibia)

The tibia (Tibia) is long at the medial part of the leg. It has shaft, proximal and distal epiphyses. It expands at its proximal and distal epiphyses; articulating at the knee and ankle joints respectively.

The proximal end of the tibia (Epiphysis proximalis tibiae) is widened by **the medial and lateral condyles (Condyles lateralis et medialis),** which aid in weight-bearing. The superior surface of each condyles have the superior articular surface **(Facies articularis superior)**, which articulates with the femoral condyles to form the knee joint. **Intercondylar eminence (Eminentia intercondylaris)** locates between the condyles. Two tubercles are distinguished in it: **the medial and lateral intercondylar tubercles (Tuberculum intercondylare mediale et laterale)**, which articulate with the intercondylar fossa of the femur. An area intercondylaris anterior tibia (area intercondylaris anterior tibiae) is located anterior to the intercondylar eminence. The posterior intercondylar area **(Area intercondylaris posterior tibiae)** is located posterior to the intercondylar eminence between both superior articular surfaces. Both areas give attachment to the cruciate ligaments of the knee.

The posterolateral aspect of the lateral condyle of the tibia carries the articular surface for the fibula **(Facies articularis fibularis).**

The shaft/body of the tibia (Corpus tibiae) is trihedral, with three borders and three surfaces; anterior, posterior and lateral. **Anterior border (Margo anterior)** is palpable subcutaneously down the anterior surface of the leg as the shin. The proximal aspect of is the **tibial tuberosity (Tuberositas tibialis).** Lateral border **(Margo lateralis/interosseous)** is sharp and gives attachment to the interosseous membrane that binds the tibia and the fibula together. The medial border (margo medialis) is rounded. The medial surface **(Facies medialis)** is slightly convex. The lateral surface **(Facies lateralis)** is concave. The posterior surface **(Facies posterior)** is flat and marked by a ridge of bone – **soleal line (Linea musculi solei)** which runs from the lateral condyle downwards and medially.

The distal end of the tibia (Epiphysis distalis tibiae) is quadrangular. On its lateral surface it bears the fibular notch **(Incisura fibularis),** where the fibula is bound to the tibia – forming the distal tibiofibular joint. The medial border of the distal end of the tibia is the medial malleolus **(Malleolus medialis),** which is easily palpate though the skin. The lateral surface of the medial malleolus carries the articular facet **(Facies articularis malleoli mediale)** which articulates with medial side of the tarsal bones to form part of the ankle joint. The inferior surface is the concave inferior articular surface **(Facies articularis inferior tibiae)** for articulation with superior side of the tarsal bones.

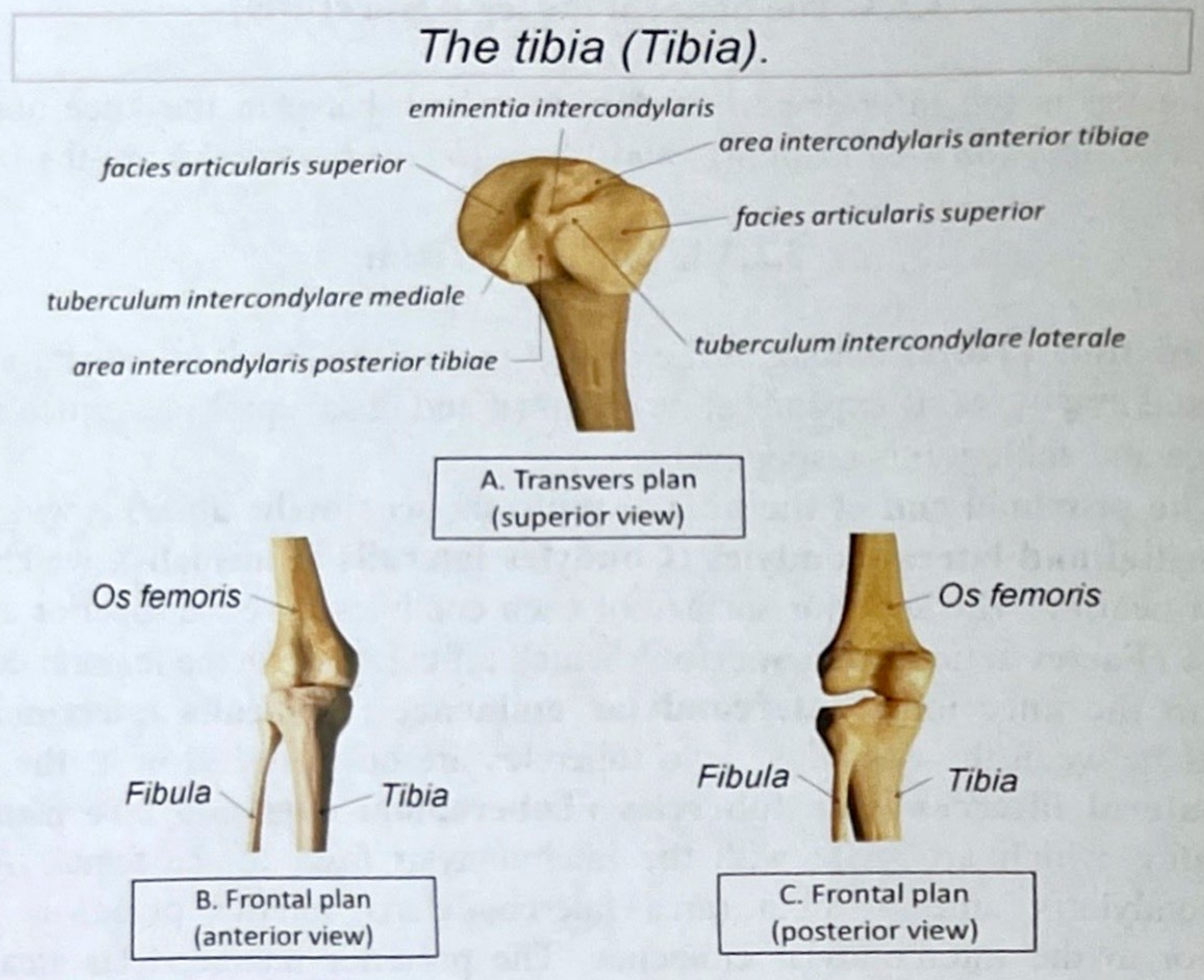

The tibia (Tibia).
eminentia intercondylaris
area intercondylaris anterior tibiae
facies articularis superior
facies articularis superior
tuberculum intercondylare mediale
area intercondylaris posterior tibiae
tuberculum intercondylare laterale
A. Transvers plan (superior view)
Os femoris
Fibula
Tibia
Os femoris
Fibula
Tibia
B. Frontal plan (anterior view)
C. Frontal plan (posterior view)

Fig. 42. The proximal end of the tibia (Epiphysis proximalis tibiae) (original fig.)

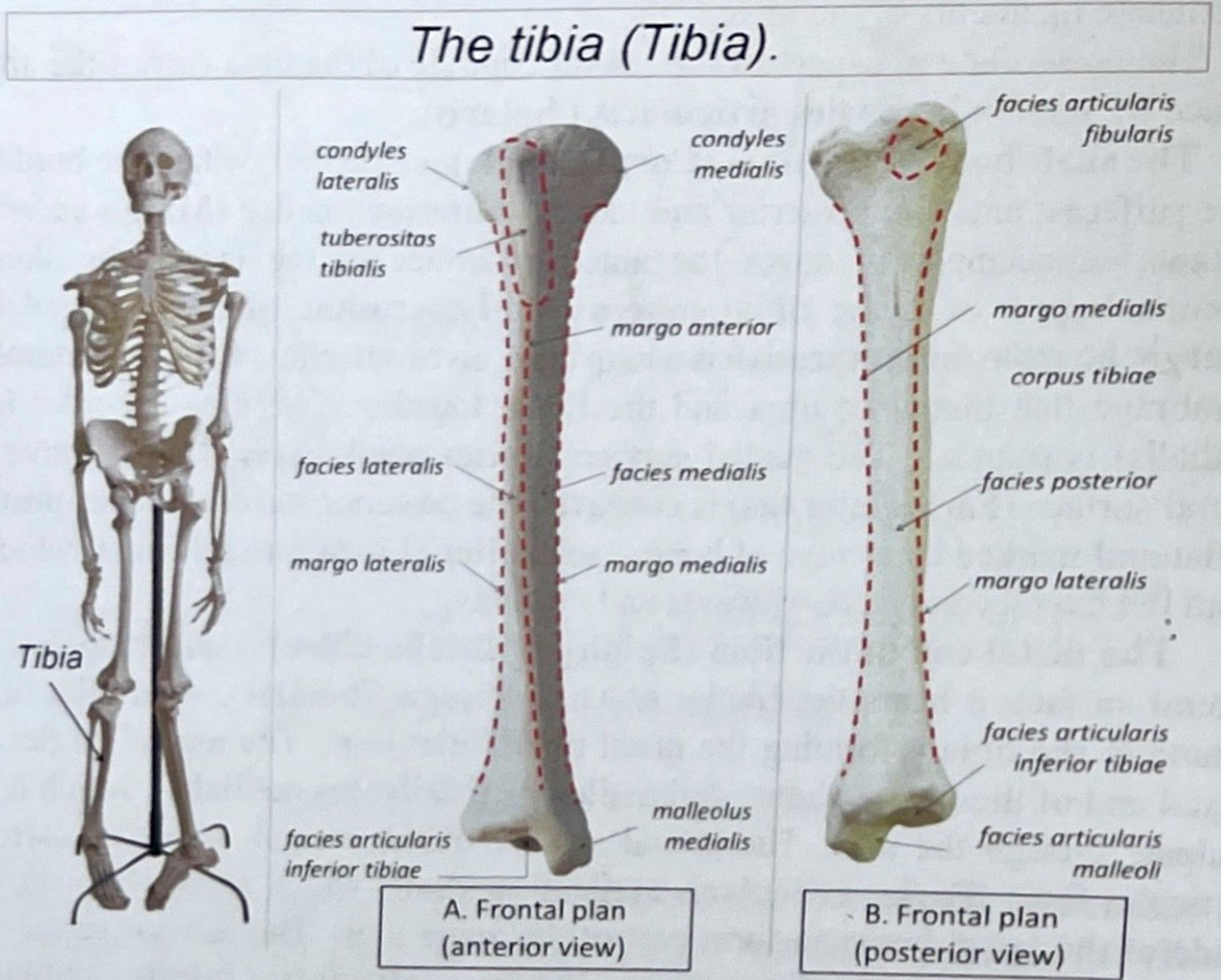


Fig. 43. The tibia (Tibia) (original fig.)

3.2.3.2. The fibula (Fibula/Os peronea)

Fibula is long bone located within the lateral part of the leg. Fibula is mainly for attachment of muscles, but it also provides the stability to the ankle joint.

The proximal end of the fibula (Epiphysis proximalis fibulae) forms the head (**Caput fibulae**). The head of the fibula is irregular knoblike part the upper part of which is called the apex of the head (**Apex capitis fibulae**). The superomedial surface of the head is the articular surface for the tibia **(Facies articularis tibialis),** articulates with the lateral condyle of the tibia (Proximal tibiofibular joint).

The body (Corpus fibulae) is trihedral, twisted about the longitudinal axis and curved to the back. It has three surfaces (**Facies lateralis, medialis, posterior**) which separated by three borders (**Margo anterior, medialis, lateralis/interosseous**).

The distal end of the fibula (**Epiphysis distalis fibulae**) is the lateral malleolus (**Malleolus lateralis**). The lateral surface of which is easily felt through the skin. The medial surface bears an articular facet for articulation with the fibular notch of the tibia and below of it an articular facet of the lateral malleolus (**Facies articularis malleoli laterale**) which articulates with the lateral side of talus bone of the foot to form part of the ankle joint.

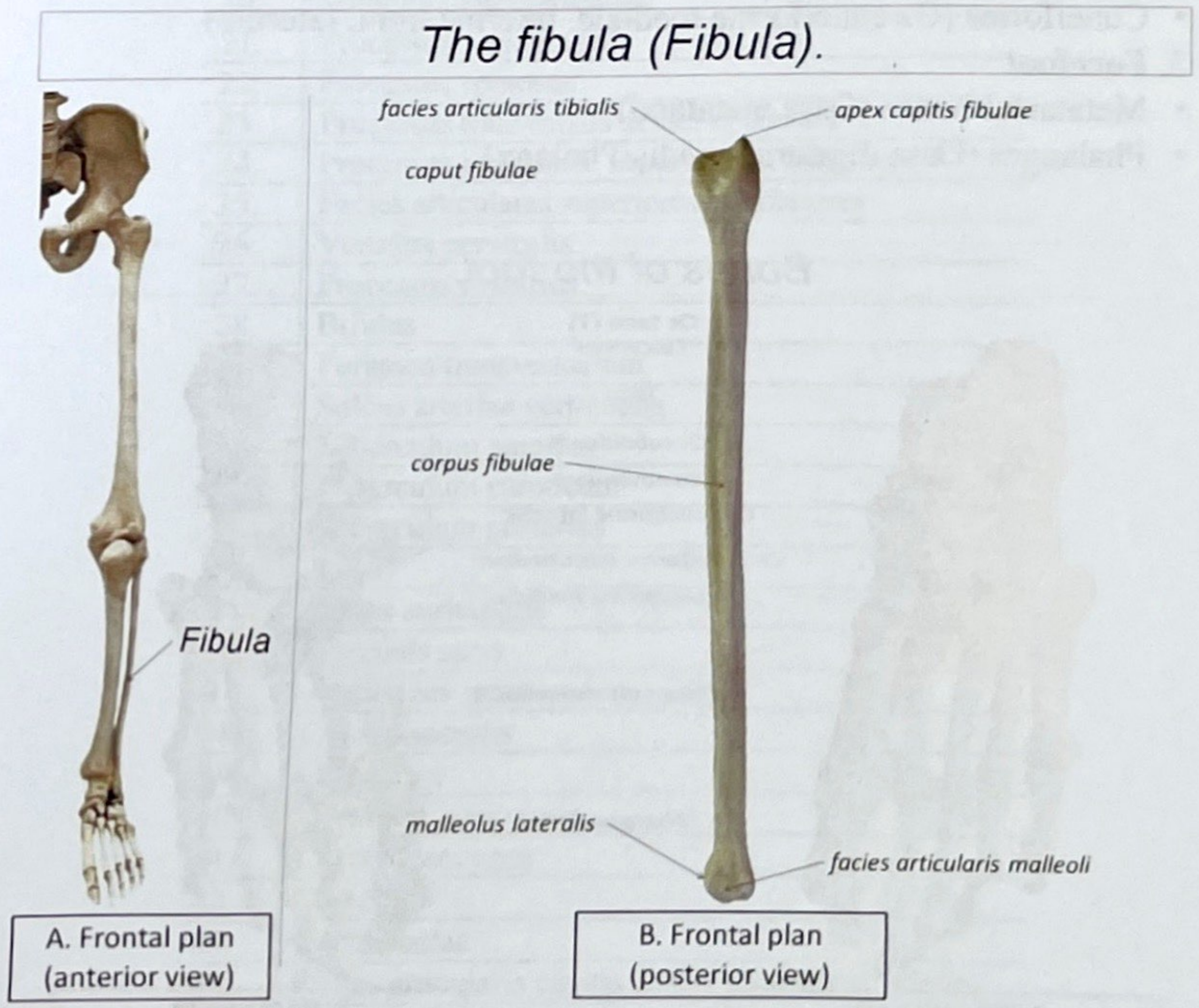

The fibula (Fibula).
facies articularis tibialis
apex capitis fibulae
caput fibulae
corpus fibulae
Fibula
malleolus lateralis
facies articularis malleoli
A. Frontal plan (anterior view)
B. Frontal plan (posterior view)

Fig. 44. The fibula (Fibula) (original fig.)

3.2.4. Bones of the foot (ossa pedis)

The bones of the foot provide mechanical support for the soft tissues; helping the foot withstands the weight of the body whilst standing and in motion.

They can be divided into three **groups**:

- **Tarsal bones (Ossa tarsi)** – a set of **seven** irregularly shaped bones. They are situated proximally in the foot in the ankle area, but only one of them, the talus, articulate with the leg bones.
- **Metatarsals (Ossa metatarsi)** – connect the phalanges to the tarsus. There are **five** in number – one for each digit.
- **Phalanges (Phalanx)** – the bones of the toes. Each toe has three phalanges – proximal, intermediate, and distal (except the big toe, which only has two phalanges).

The foot can also be divided into three **regions**:

1. **Hind foot**
- Talus (Talus)
- The heel bone/Calcaneum (Calcaneus)

2. **Midfoot**:
- Navicular (Os naviculare)
- Cuboid (Os cuboideum)
- Cuneiforms (Os cuneiforme mediale, intermedium, laterale)

3. **Forefoot**
- Metatarsal bones (Ossa matatarsi)
- Phalanges (Ossa digitorum pedis/Phalanx)

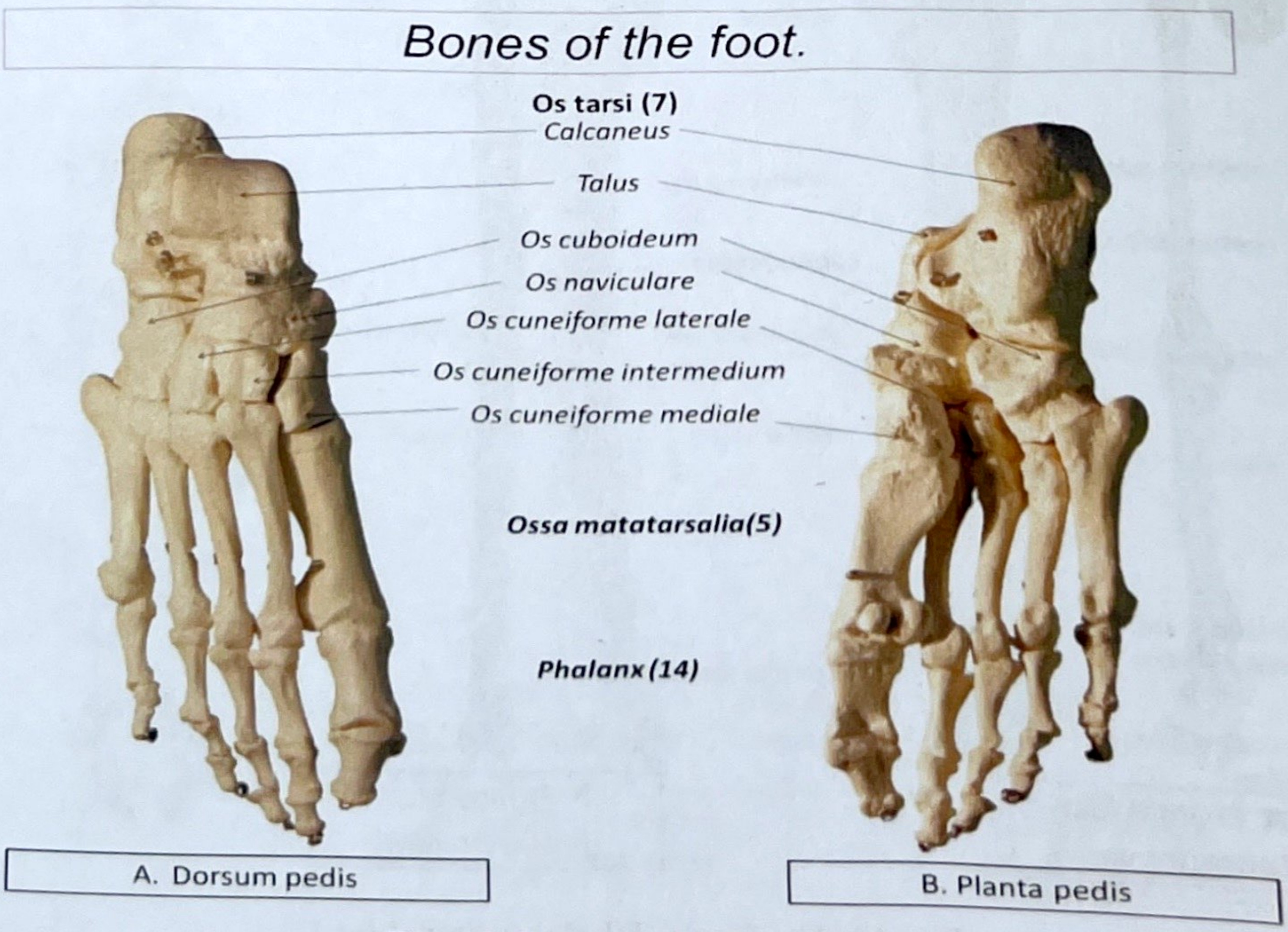


Fig. 45. Bones of the foot (original fig.)

List of anatomical terms in latin language for the test on osteology

1.	Ossa trunci
2.	Columna vertebralis
3.	Pars cervicalis columnae vertebralis
4.	Pars thoracica columnae vertebralis
5.	Pars lumbalis columnae vertebralis
6.	Pars sacralis columnae vertebralis
7.	Pars coccygea columnae vertebralis
8.	Os sacrum
9.	Os coccygis
10.	Vertebra
11.	Corpus vertebrae
12.	Foramen nutricia
13.	Arcus vertebrae
14.	Foramen vertebrale
15.	Canalis vertebralis
16.	Pediculus arcus vertebrae dexter et sinister
17.	Laina dextra et sinistra
18.	Incisura vertebralis superior
19.	Incisura vertebralis inferior
20.	Foramina intervertebrale
21.	Processus vertebrales
22.	Processus spinosus
23.	Processus transversus dexter et sinister
24.	Processus articulares superiores et inferiores
25.	Facies articulares superiores et inferiores
26.	Vertebra cervicalis
27.	Processus costarius
28.	Bifidus
29.	Foramen transversarium
30.	Sulcus arteriae vertebralis
31.	Tuberculum anterius
32.	Tuberculum caroticum
33.	Tuberculum posterius
34.	Atlas
35.	Facies auricularis
36.	Ala ossis sacri
37.	Apex ossis sacri
38.	Cornua sacralis
39.	Os coccyx
40.	Vertebrae coccygeae
41.	Cornua coccygea
42.	Costae
43.	Caput costae
44.	Facies articularis capitis costae superior et inferior
45.	Crista capitis costae
46.	Collum costae
47.	Tuberculum costae

48.	Facies articularis tuberculi costae
49.	Corpus costae
50.	Angulus costae
51.	Sulcus costae
52.	Cartilagines costales
53.	Costae verae
54.	Costae spuriae
55.	Costae fluctuantes
56.	Costa prima (I)
57.	Sulcus arteria subclaviae
58.	Sulcus venae subclaviae
59.	Tuberculum musculi scalene anterioris
60.	Costae secunda (II)
61.	Tuberositas musculi serrati anterioris
62.	Sternum
63.	Manubrium sterni
64.	Incisura jugularis
65.	Incisura clavicularis
66.	Incisurae costales
67.	Corpus sterni
68.	Angulus sterni
69.	Incisurae costales
70.	Processus xiphoideus
71.	Cavitas thoracis
72.	Arcus costalis
73.	Angulus infrasternalis
74.	Sulci dorsales
75.	Foramen costotransversarium
76.	Sulci pulmonales
77.	Apertura thoracic superior
78.	Apertura thoracic inferior
79.	Ossa membri superioris
80.	Cingulum pectorale/Cingulum membri superior
81.	Corpus humeri
82.	Tuberositas deltoidea
83.	Sulcus radialis/spiralis
84.	Ulna
85.	Epiphysis proximalis ulnae
86.	Olecranon
87.	Process coronoideus
88.	Incisura trochlearis
89.	Incisura radialis
90.	Diaphysis ulnaris
91.	Margo posterior, interosseus et anterior
92.	Facies anterior, posterior et medialis
93.	Tuberositas ulnae
94.	Epiphysis distalis ulnae
95.	Caput ulnae
96.	Circumferentia articularis ulna
97.	Processus styloideus medialis

98.	Radius
99.	Caput radii
100.	Circumferentia articularis radii
101.	Collum radii
102.	Tuberositas radii
103.	Corpus radii
104.	Margo anterior, posterior et interosseous radii
105.	Facies anterior, posterior et lateralis radii
106.	Foramen nutricicum
107.	Tuberositas pronatoria
108.	Processus styloideus radii
109.	Incisura ulnaris
110.	Tuberculum dorsalis
111.	Ossa manus
112.	Ossa carpi
113.	Os scaphoideum
114.	Os lunatum
115.	Os triquetrum
116.	Os pisiformis
117.	Os trapezium
118.	Os trapezoideum
119.	Os capitatum
120.	Os hamatum
121.	Ossa metacarpi
122.	Basis ossis metacarpi
123.	Corpus metacarpi
124.	Caput metacarpi
125.	Spatiae interosseae metacarpi
126.	Ossa digitorum (Phalanges)
127.	Phalanges digitorum
128.	Phalanx proximalis
129.	Phalanx media
130.	Phalanx distalis
131.	Basis phalangis
132.	Corpus phalanges
133.	Caput phalangis
134.	Ossa membri inferioris
135.	Condyles lateralis et medialis
136.	Eminentia intercondylaris
137.	Tuberculum intercondylare mediale et laterale
138.	Area intercondylaris posterior tibiae
139.	Facies articularis fibularis
140.	Corpus tibiae
141.	Margo anterior tibiae
142.	Tuberositas tibialis
143.	Margo lateralis/interosseous tibiae
144.	Facies medialis tibiae
145.	Facies lateralis tibiae
146.	Facies posterior tibiae
147.	Linea m. solei

148.	Epiphysis distalis tibiae
149.	Incisura fibularis
150.	Malleolus medialis
151.	Facies articularis malleoli mediale
152.	Facies articularis inferior tibiae
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